

# Fibrous Monolith Wear Resistant Components for the Mining Industry

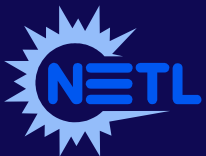
- **Principal Investigator:** M.J. Rigali, Advanced Ceramics Research, Inc. Tucson, AZ
- **NETL Project Manager:** Morgan Mosser
- **Partners:** Advanced Ceramics Manufacturing; Kyocera Corporation; Phelps Dodge Sierrita; Phelps Dodge Bagdad; The University of Arizona; Krebs Engineering; University of California Santa Barbara; Inco LTD.
- **Total Project Cost:** **\$5,442,399**
  - DOE Share: \$2,696,005
  - Participant Share: \$2,746,394
  - Project Period: 36 months
- **Project Start Date: 22 Feb. 2001**



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# Project Objectives

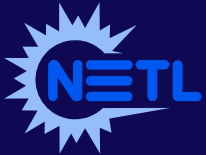
- To develop advanced materials for wear resistant components using our patented fibrous monolith processing technology and overcome the cost/performance barrier traditionally associated with advanced materials. The developed components will show a significant increase in wear life while remaining cost competitive with current wear resistant components. The targeted components include mining drill bit inserts, point-attack tools, dozer teeth, and hydro-cyclone apex cones



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# Photo Library

## Fibrous Monolith Coatings for Mining Drill Bit Inserts



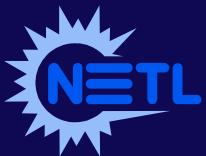
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# Photo Library



**WC-6%Co/WC-16%Co Fibrous Monolith conical tool insert prototypes ground by KYOCERA (left) and WC-6%Co/WC-16%Co Fibrous Monolith ground by Imperial Carbide (right).**

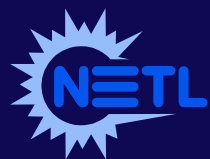
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# Photo Library



**Abrasion testing equipment (left) and tested WC(6%)Co/WC(16%)Co FM sample (right).**



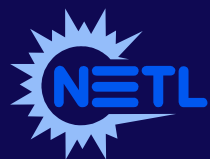
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# Photo Library



**Sintered MoSi<sub>2</sub> ceramic electrowinning test wafers (left) and sintered SiC+YAG ceramic electrowinning test wafers (right) delivered to Hazen research for cyclic voltammetry.**

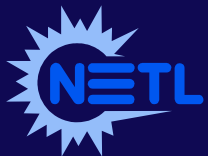


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# Milestones and Status

## Major Milestones Planned to Date/Status

<u><i>Planned Milestone</i></u>	<u><i>Scheduled</i></u>	<u><i>Completed</i></u>
– Project Management Plan	2/22/01	2/22/01
– Complete drill bit material trade study	4/17/01	7/6/01
– Complete cyclone apex cone trade study	4/17/02	4/1/03
– Complete electro-winning material trade study	7/15/02	7/15/02
– Complete point attack tool trade study	3/21/03	12/15/01
– Complete drill bit insert lab testing	12/31/02	Ongoing
– Complete dozer blade insert lab testing	12/31/02	Ongoing
– Complete cyclone apex cone lab testing	12/31/02	



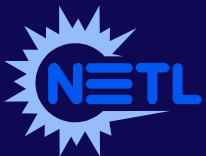
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# Milestones and Status

## Major Milestones Planned to Date/Status

<u>Planned Milestone</u>	<u>Scheduled</u>	<u>Completed</u>
– Complete electro-winning anode lab. testing	9/15/02	Ongoing
– Complete point attack tool lab testing	7/21/03	Ongoing
– Complete electro-winning anode field testing	9/30/02	
– Complete drill bit insert field testing	10/31/03	Ongoing
– Complete cyclone apex cone field testing	7/31/03	
– Complete dozer blade insert lab testing	10/31/03	
– Complete point attack tool field testing	12/31/03	
– Deliver Report of Termination/Complete Report	2/20/04	
– Final Report	2/20/04	

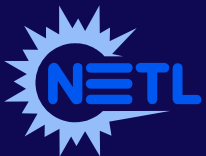
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# Milestones and Status

- **Key Decision Points Remaining**
  - **Apex Cone Materials Trade Study**
    - The down-selected FM materials offer an improvement in wear resistance based on laboratory abrasion testing, but no cost benefit when compared to conventional monolithic materials such as SiC.
  - **Result of Drill Bit Insert Laboratory Testing**
    - The FM inserts demonstrated a **3X** improvement in wear resistance when compared to monolithic WC inserts with the same bulk Co content (~8%) using the high stress abrasion tester (see Photo archive).
  - **Result of Dozer Blade Insert Laboratory Testing**
    - Based on laboratory wear testing of the insert material, it is expected that the WC-Co(6%)/WC-Co(16%) FM material will demonstrate similar improvement in the blade insert application.



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# Milestones and Status

- **Key Decision Points Remaining (cont'd)**

- Result of Apex Cone Laboratory Testing**

- Due to trade study results, no apex cone lab testing will be performed.

- Result of Electrowinning Anode Laboratory Testing**

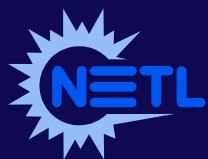
- The laboratory testing demonstrated no conductivity for SiC. This was also true for the  $Zr_2O_3$  sample at room temperature. It remains to test  $MoSi_2$ ,  $NbSi_2$  and  $SnO_2$ .  $NbSi_2$  currently being fabricated.

- Result of Point Attack Tool Laboratory Testing**

- Based on laboratory wear testing of the insert material, it is expected that the WC-Co(6%)/WC-Co(16%) FM material will demonstrate similar improvement in the point attack tool application.

- Result of Drill Bit Insert Field Test**

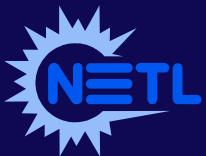
- Field testing currently scheduled April/May.



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# Milestones and Status

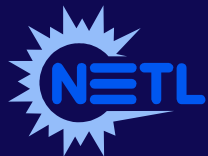
- **Key Decision Points Remaining (cont'd)**
  - **Result of Electrowinning Anode Field Testing**
    - Was the field testing successful in demonstrating increased life and corrosion/oxidation resistance in the electro-winning anode application?
  - **Result of Apex Cone Field Testing**
    - Based on trade study Apex Cone will not be fabricated.
  - **Result of Dozer Blade Insert Field Test**
    - Was the field test successful in demonstrating increased wear life and damage tolerance in the dozer blade application?
  - **Result of Point Attack Tool Field Test**
    - Was the field test successful in demonstrating increased wear life and damage tolerance in the point attack tool application?



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# Milestones and Status

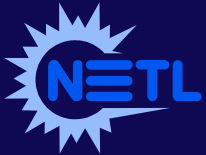
<b><i>Decision Point</i></b>	<b><i>Scheduled Date</i></b>	<b><i>Is it a go/no-go decision?</i></b>
<b><i>Results of drill bit insert material trade study</i></b>	<b><i>April/2001 Completed June 2001</i></b>	<b><i>Go</i></b>
<b><i>Results of apex cone material trade study</i></b>	<b><i>April 2002 Complete April 2003</i></b>	<b><i>No-Go</i></b>
<b><i>Results of electro-winning anode material trade study</i></b>	<b><i>7/15/02 Completed July 2003</i></b>	<b><i>Go</i></b>
<b><i>Results of point attack tool material trade study</i></b>	<b><i>3/21/2003 Completed December 2001</i></b>	<b><i>Go</i></b>
<b><i>Results of drill bit insert lab. testing</i></b>	<b><i>12/31/02 Ongoing</i></b>	<b><i>Go</i></b>



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# Milestones and Status

<b><i>Decision Point</i></b>	<b><i>Scheduled Date</i></b>	<b><i>Is it a go/no-go decision?</i></b>
<b><i>Results of dozer blade insert lab. testing</i></b>	<b><i>12/31/02 Ongoing</i></b>	<b><i>Go</i></b>
<b><i>Results of apex cone lab. testing</i></b>	<b><i>12/31/02</i></b>	<b><i>No-Go</i></b>
<b><i>Results of electro-winning anode lab. testing</i></b>	<b><i>9/15/02 Ongoing</i></b>	<b><i>Go/No-Go</i></b>
<b><i>Results of point attack tool lab. testing</i></b>	<b><i>7/21/03 Ongoing</i></b>	<b><i>Go</i></b>
<b><i>Results of drill bit insert field testing</i></b>	<b><i>10/31/03 1<sup>st</sup> test in Q2 2003</i></b>	<b><i>Go/No-Go</i></b>

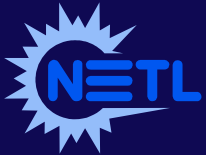


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# Milestones and Status

<b><i>Decision Point</i></b>	<b><i>Scheduled Date</i></b>	<b><i>Is it a go/no-go decision?</i></b>
<b><i>Results of cyclone apex cone field testing</i></b>	<b><i>10/31/03</i></b>	<b><i>No-Go</i></b>
<b><i>Results of dozer blade insert field testing</i></b>	<b><i>10/31/03</i></b>	<b><i>Go/No-Go</i></b>
<b><i>Results of point attack tool field testing</i></b>	<b><i>12/31/03</i></b>	<b><i>Go/No-Go</i></b>



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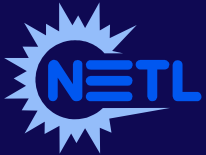
# Key Accomplishments

- First 7/8" inch WC-6%Co/WC-16%Co drill bit inserts for Superior Rockbit Co. (Virginia, MN) tri-cone roller bit delivered for field testing on Dec.20<sup>th</sup> 2002. Bits are scheduled to be field tested in early April 2003.
- FM inserts demonstrated a **3X** improvement in wear resistance (per ASTM B-661) when compared to a monolithic insert with the same bulk Co content (~8%).
- Laboratory testing demonstrated potential for NbC as anode material, but corrosion remains an issue. Samples of TiO<sub>2</sub>, ZrO<sub>2</sub>, MoSi<sub>2</sub>, SiC, and NbSi<sub>2</sub> to be evaluated in Q2.



# Project Recognition

- Abstract entitled “Tungsten Carbide Fibrous Monoliths for Mining Applications” submitted to ASM International 2003 Materials Solutions Conference, October 13-16 2003, Pittsburg,PA.



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# Commercialization Outlook

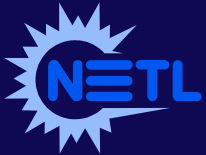
- The program continues to show significant commercial interest by Kennametal, Smith Bits, Superior Rockbit and Kyocera.



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# Calibration Methods for On-Line Analyzers

- **Principal Investigator:** Rajive Ganguli - University of Alaska at Fairbanks
- **NETL Project Manager:** Morgan Mosser
- **Partners:** Usibelli Coal Mine; Golden Valley Electric Association
- **Total Project Cost:** **\$335,983K**
  - DOE Share: \$158,227K
  - Participant Share: \$177,756K
- **Project Period:** **30 months**
- **Project Start Date:** **Dec. 18, 2000**

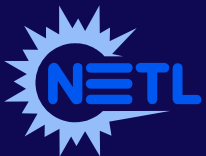


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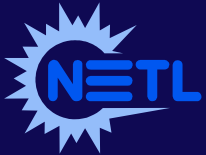
# Project Objectives

- This project aims to apply neural networks (NN) for calibration of on-line analyzers. The factors that play a role in determining the analyzer reading will be first identified.
- These factors will be inputted into the back propagation neural network that will be developed as part of the project.
- Using data to be collected, the neural network will be trained. The trained network will then be used to determine coal ash values.

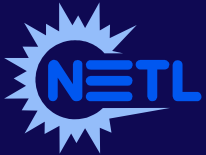
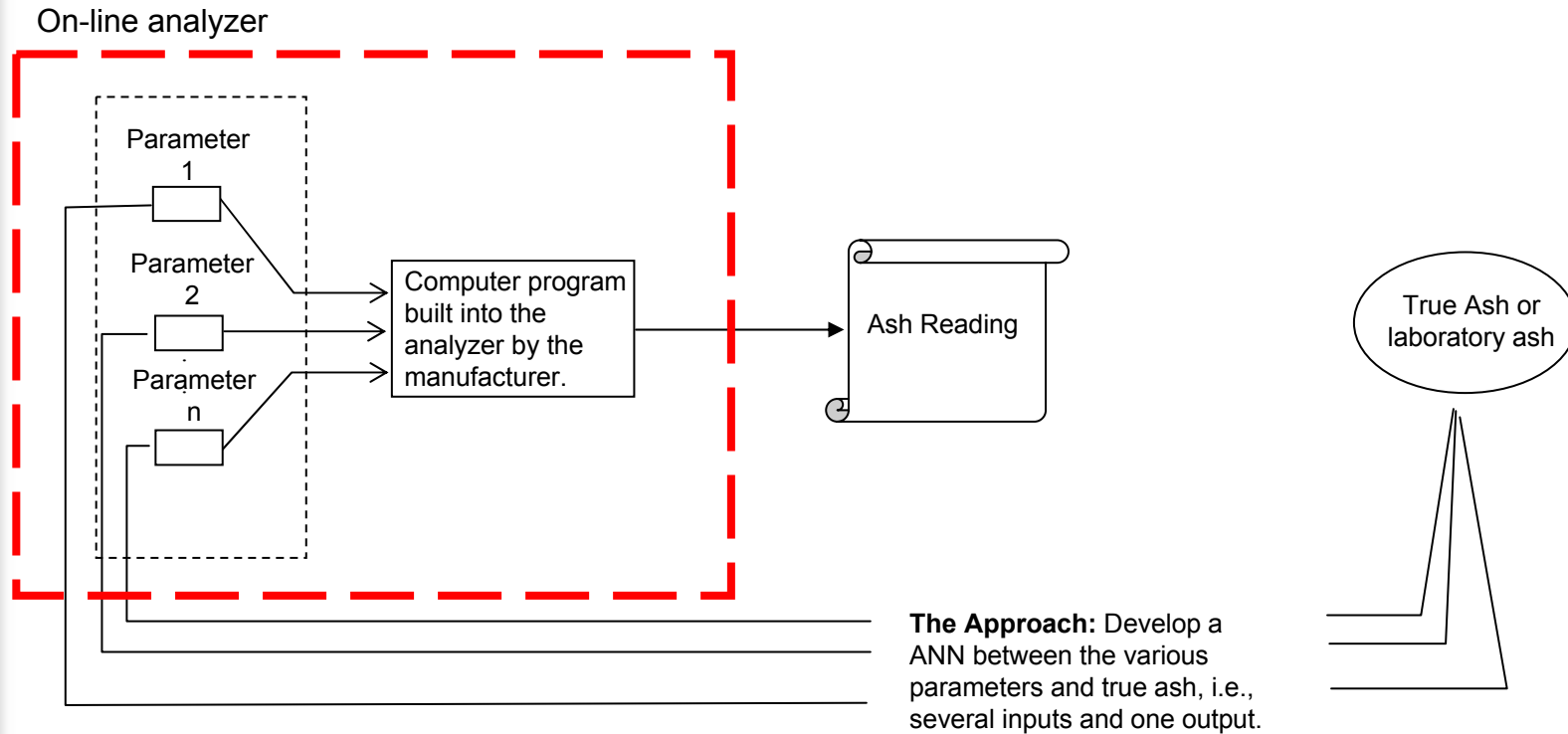


# Project Objectives (Con't)

- **Approach to be tested:**
  - Develop a neural network between the Am and Cs readings of the analyzer and the true ash as determined by the laboratory.
- **This approach will bypass the *parameter-ash* relationship pre-defined by the manufacturer and develop one of its own.**



# The Approach



# Milestones and Status

## Major Milestones Planned to Date/Status

<u><i>Planned Milestones</i></u>	<u><i>Scheduled</i></u>	<u><i>Completed</i></u>
– Literature Review	06/2002	X
– Sampling	06/2002	X
– Development of Neural Network	12/2002	X
– Application of neural network	03/2003	X
– Documentation	06/2003	

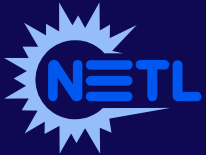


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# Key Accomplishments

- **Project Highlights**

- Literature review completed
- On-line analyzer manufacturers from France (Sodern) and Australia (Coalscan) have expressed interest and are participating by sharing knowledge.
- Sampling
  - Issues resolved
  - Sampling done at Usibelli.
- Data shared by GVEA (from prior to the project) found not useful.

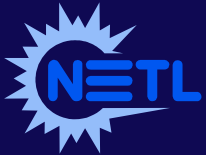


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# Project Recognition

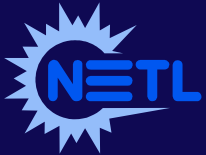
- **Review paper was published in the international journal “Mineral Resources Engineering”.**
  - Ganguli, R., 2001, “A Critical Review of Analyzers,” Mineral Resources Engineering, Vol. 10, No. 4 (December), pp. 435-445.
- **Paper presented in SME Annual Meeting '03 (Cincinnati). It will also be peer reviewed.**
  - Yu, S., Ganguli, R., Walsh, D.E., Bandopadhyay, S. and Patil, S.L., “Calibration of Online Analyzer Using Neural Networks,” Pre-print #03-047
- **Peer reviewed paper accepted for APCOM 03 (Capetown, South Africa) on work done in the project.**
  - Ganguli, R. and Bandopadhyay, S., “Neural Network Architecture vs. Network Performance for a Quick Stop Application”



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# Good News!

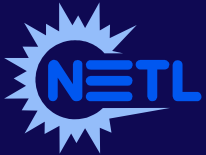
- **Software developed in C++ that reads analyzer readings and applies neural network. Software testing to begin soon.**
- **Unbiased neural networks developed for both screened and unscreened coal.**



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# Projectile Based Excavation

- **Principal Investigator:** Shyke Goldstein, Advanced Power Technologies, Inc.
- **NETL Project Manager:** Morgan Mosser
- **Partners:** Lafarge Corporation; Baker Hughes Mining Tools; University of Utah
- **Total Project Cost:** **\$1,557,831**
  - DOE Share: \$777,831
  - Participant Share: \$780,000
- **Project Period:** **36 months**
- **Project Start Date:** **Feb. 7, 2001**



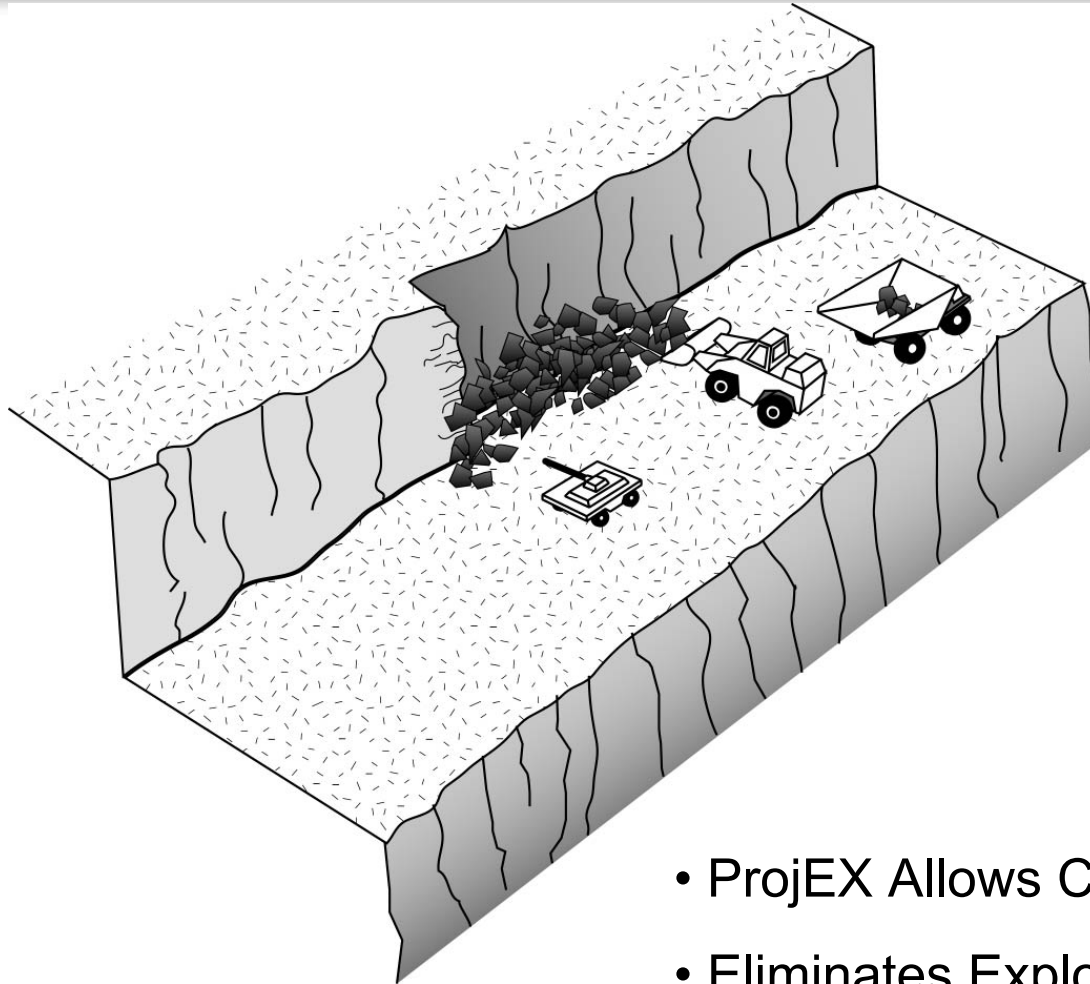
# Project Objectives

- **Develop new technologies to improve the efficiency of the mineral production process and improve the safety and efficiency of the extraction process**
- **APTI proposes to address these goals specifically through the development of a low cost projectile system for the rapid, efficient, excavation applicable to all forms of surface and subsurface mining**
- **The system called ProjEX is based on two APTI developments**



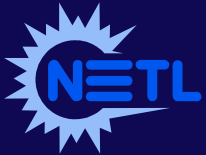
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# ProjEX Provides Lower Cost/Ton Production



- ProjEX Allows Continuous Mining
- Eliminates Explosives From Mine

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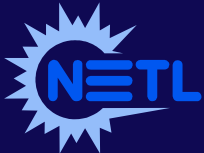


# Milestones and Status

## Major Milestones Planned to Date/Status

### Planned Milestones

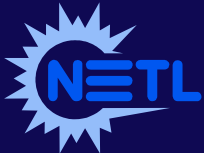
	<u>Scheduled</u>	<u>Completed</u>
– Phase I : Prototype projectile development.	12/2001	
• Design projectile alternatives	10/01	12/01
• Develop electric fired/conventional propellant test gun system	10/01	3/02
• Conduct firing tests using conventional propellants		
• Start	5/02	5/02
• Complete	11/02	12/02
• Evaluate projectile performance	11/02	12/02
– Phase II : Transition from conventional propellants to electric	1/03*	
• Develop electric propulsion system for testing concept		
• Conduct firing tests using electric propulsion in lab and field		
• Design of prototype ProjEX System		
– Phase III. : Prototype development	1/04	
• Development of prototype ProjEX System		
• System testing		
• Review Prototype results		



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# Key Accomplishments

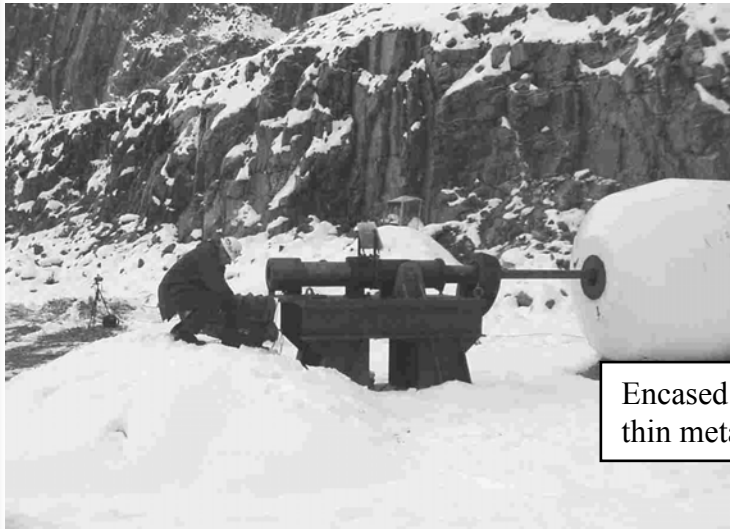
- **Project Highlights**
  - **60 mm Launcher system**
    - Successful quarry testing continues.
    - Launcher components performing as designed. Muffler reduces acoustic signature well below MSHA limit.
  - **Projectile**
    - Several designs tested in field.
    - More robust design successful - more costly – compromise being sought.
  - **Field Tests**
    - Field testing continued through mid December.
  - **Program Direction Change?**
    - APTI proposes change in focus from Productive Mining to Secondary Breakage.
    - Reasons:
      - High Cost of Electric Launch Development (components not obtained from Army Research Lab)
      - Industry interest
      - Lower cost of commercialization
    - Status:
      - APTI seeking new mining equipment partner to replace Baker Hughes – share in-kind contribution
      - If not successful, may cause termination of program.



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# Good News!

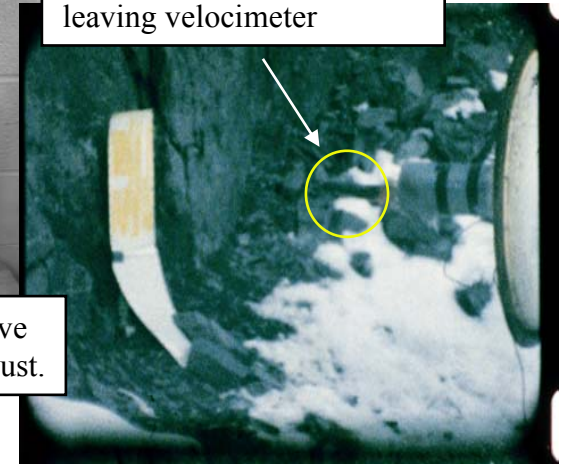
Full scale testing continues by APTI in Lafarge quarry using limestone quarry wall. Tests have determined that more robust projectiles are successful at high velocity (1.3 km/sec) – produce  $\sim 1/3$  m<sup>3</sup> of muck. Higher velocity ( $\sim 1.5$  km/s), within capability of launcher should yield higher production.



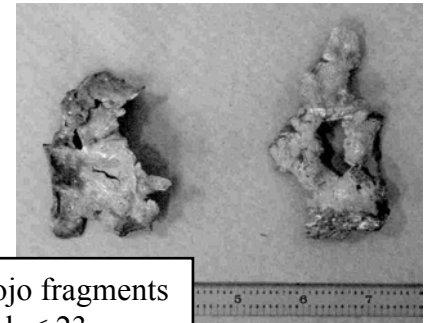
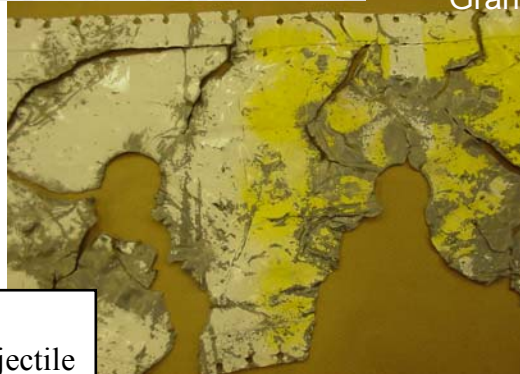
Encased 60 mm projos have thin metal skin - more robust.



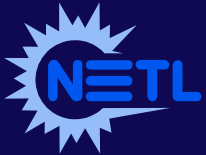
Projectile in flight – just leaving velocimeter



Typical witness plates showing survival of projectile at  $\sim 1.3$  km/s.



Largest projo fragments found weigh < 23 gm



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# Commercialization Outlook

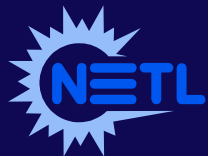
- APTI trying to identify new industrial partner to replace withdrawal of Baker Hughes.
- Lafarge and many other mining companies express interest in Secondary Breakage.
- Uses equipment on hand at APTI – will require modification.
- Will require Quarry testing.
- Outlook questionable – driven by ability to find new industrial partner with cash in-kind contribution.
- **APTI sent letter requesting termination and close-out of the project due to loss of mining partner**



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# Metal - Matrix Composites and Thermal Spray Coatings for Mining Machines

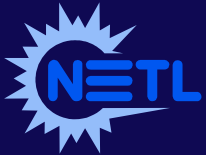
- **Principal Investigator:** Matthew Kiser, Caterpillar Inc.
- **NETL Project Manager:** Morgan Mosser
- **Partners:** Oak Ridge National Laboratory  
Albany Research Center  
St. Louis Metallizing,  
State University of New York at Stony Brook,  
University of California at Santa Barbara
- **Total Project Cost:**  
**\$1,323,187 (Including ARC & ORNL)**
  - DOE Share: \$661,522 (\$560,522 w/o ARC & ORNL)
  - Participant Share: \$661,665 (\$572,798 w/o ARC & ORNL)
- **Project Period:** 26 months
- **Project Start Date:** Feb. 7, 2001



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# Project Objectives

- **Develop cost effective processes to permit the implementation of advanced abrasion resistant materials**
- **Intended Benefits**
  - 50% reduction in scheduled downtime by increasing wear component (bucket tips, undercarriage,....) life by over 2X
  - Increased Energy Efficiency
    - Processing of fewer replacement parts
    - Increased tool efficiency through selective abrasion resistant material placement.
  - Reduced Operating Costs



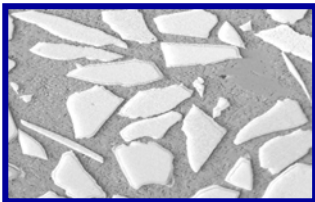
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# Metal-Matrix Composites and Thermal Spray Coatings for Mining Machines



Thermal  
Spray  
Coatings



Steel Matrix  
Composites

- Reduce Downtime by 50% Through Implementation of:
  - Steel Metal Matrix Composites
  - Thermal Spray Coatings
- Realize Energy Savings Through:
  - Processing of fewer replacement parts
  - Improved tool efficiency and weight through optimal placement of coatings and hard particles

## Team Members:

Caterpillar, ORNL, ARC, St. Louis  
Metallizing, State Univ. of NY at  
Stoney Brook, Univ. of California at  
Santa Barbara

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# Milestones and Status

## Major Milestones Planned to Date/Status

### Planned Milestones

### Scheduled   Completed

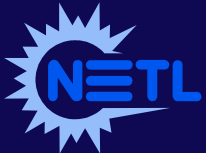
✓ Process Development - MMC	12/2001	8/02*	8/2002
✓ Cost Analysis	<u>02/2002</u>	4/02	4/2002
✓ Design and analysis	<u>06/2002</u>	8/02	10/2002
✓ Spray Coating Development – Uniform	05/2002	**	5/2002
✓ Spray Coating Development – Functionally Graded Coatings	09/2002		9/2002
✓ Material Properties	12/2002		12/2002
✓ Process development for Prototype Components – Spray Coatings	12/2002	***	12/2002
✓ Perform further process improvements to improve coating performance.	03/2003		03/2003
• Complete Final Reports and Documentation	05/2003		

\* Delayed due to late arrival of tooling for MMCs.

\*\* Additional milestone added to express unique development phases for coatings. Materials and processes for uniform coatings have been identified. Development of graded coatings (FGMs) will now start.

\*\*\* Sprayed coatings only.

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# Milestones and Status

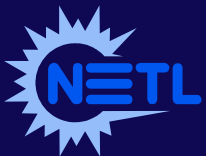
## Key Decision Points Remaining

<i>Decision Point</i>	<i>Scheduled Date</i>	<i>Is it a go/no-go decision?</i>
<i>Confirm technical and cost feasibility of processes</i>	<i>02/2002 Actual 10/2002</i>	<i>Y*</i>
<i>Complete trials showing FeMMC processing may be scaled to component.</i>	<i>12/2002</i>	<i>Y**</i>

**\* Performance and cost data suggest that use of the currently developed ferrous MMCs are only marginally acceptable, however use of sprayed coatings can be justified.**

**\*\* Development of coatings for carbide cermet particle to improve infiltration and reduce particle dissolution should permit conventional gravity casting of current components. Given cost/performance findings, a representative prototype casting was not made to explore this.**

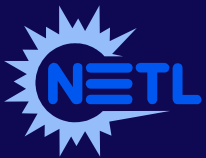
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# Key Accomplishments

## Ferrous Metal-Matrix Composites

- Completed analysis of composite wear surfaces
  - Oxide particles provided better gouging wear resistance over cemented carbides particles.
  - Carbides in steel matrix of cemented carbide particle composites provide added wear resistance.
- Fracture toughness testing complete – awaiting summary report from UC Santa Barbara



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# Key Accomplishments

## Thermally Processed Sprayed Coatings

- Second Fusing Trials of Full-scale Coated Components
  - Fifteen FGM coatings were fused by arc lamp (three basic FGM material schemes).
  - Little or no cracking of the coatings was observed after fusing.
  - Wear testing of these coatings is planned in coming months.



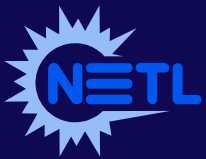
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# Commercialization

- Laboratory Full-scale Component Testing



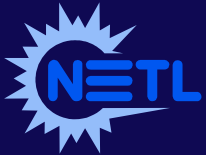
Arc lamp fused coatings on cylindrical substrates. FGM coatings are approximately 1mm in thickness and differ compositionally. Coating cracking has essentially been eliminated through proper substrate preheating and cooling.



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# Horizon Sensing

- **Report Period Start Date:** January 2003
- **Report Period End Date:** March 2003
- **Principal Investigator/Author:** Larry G. Stolarczyk
- **Project Period:** 36 months
- **Project Start Date:** 20 December 2000
- **Report Issue Date:** 10 April 2003
- **DOE Award No.:** DE-FC26-01NT41050
- **Name of Submitting Organization:** Stolar Research Corp.
- **Address:** 848 Clayton Highway  
Raton, NM 87740
- **NETL Project Manager:** David M. Hyman
- **Total Project Cost:** \$1,740,039.00
  - DOE Share: \$779,750.00
  - Participant Share: \$960,289.00



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# Abstract

**Real-time horizon sensing on continuous mining machines is becoming an industry tool. Installation and testing of production-grade HS systems has been on-going this quarter at Monterey Coal Company (ExxonMobil), Oxbow Mining, FMC Trona, and Blue Mountain Energy. Detailed monitoring of system function, user experience, and mining benefits is ongoing. All horizon sensor components have finished MSHA (U.S.) and IEC (International) certification.**

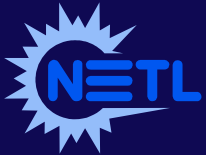


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# Project Objectives

**To demonstrate the feasibility of real-time stress measurement, bit loading, and horizon sensing on a longwall shearer, boring machine, continuous miner, and loading bucket**



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# Experimental Timeline

## Major Milestones Planned to Date/Status

### Planned Milestone

### Complete Date-%

- Completed Certification (US and Aus.) Sept. 02 – 100%
- Dual Frequency Capability HS Nov. 02 - 100%
- Accelerometer Triggering Feb. 03 - 100%
- Clean Coal Technology Program (Illinois) Feb 03 - 100%
- U.S. Production Miners (4 Total) March 03 - 100%
- U.S. Longwall Shearers (3 Total) March 03 - 100%
- Clean Coal Technology Program (Ohio) March 03 - 100%
- Forward-Detecting Radar Development March 03 - 20%



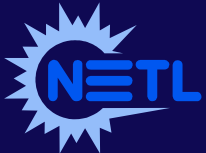
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# Results and Discussion

## Project Progress to Date Highlights

- Field Installation Approval (RAMP) complete for all 2G-approved Joy 12CM-12 continuous miners, all Joy 4LS longwall shearers, and Marietta Bore Miners
- Field Installation Approval (RAMP) underway for Joy 7LS Shearers, DBT Shearers, Voest-Alpine and Superior Continuous Miners
- HS-CM installations and performance evaluations with Monterey (EXXON), FMC Trona, Twentymile (RAG), Oxbow Mining, and West Elk Mining (ARCH) through March 2003
- HS-LW installations and performance evaluations with Monterey (EXXON), Deserado (Blue Mountain Energy), and Ohio Valley Coal (Mine No. 6) through March 2003
- Two major technical improvements: Dual frequency sensor capability has improved range and discrimination, and accelerometer based triggering has reduced background noise (higher signal/noise ratio)
- Larger battery packs for the shearer cutter heads have been built and approved (MSHA) which increase life span by a factor of 4
- HS-Radar development has begun in March 2003 for forward-looking void detection

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# Results and Discussion

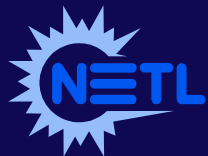
## Three New Field Installations

- 1) HS-Longwall Shearer: Deserado Mine, Rangley Colorado  
Joy 4LS Shearer with Dual-Sensor Configuration
- 2) HS-Continuous Miner : West Elk Mine, Paonia Colorado  
Joy 12CM-12 Continuous Miner
- 3) HS-Longwall Shearer : Ohio Valley Coal Mine, Ohio  
Joy 7LS Shearer with Dual-Sensor Configuration

## Pending Field Installations

- 1) HS-Continuous Miner : Consol Mine (TBD), Pennsylvania  
Voest-Alpine ABM-14 Continuous Miner
- 2) HS-Continuous Miner : Massey Mine (TBD), Kentucky  
Superior Highwall Miner
- 3) HS-Bore Miner : FMC Trona, Green River, Wyoming  
EIMCO Marietta with Arm-Sensor Configuration

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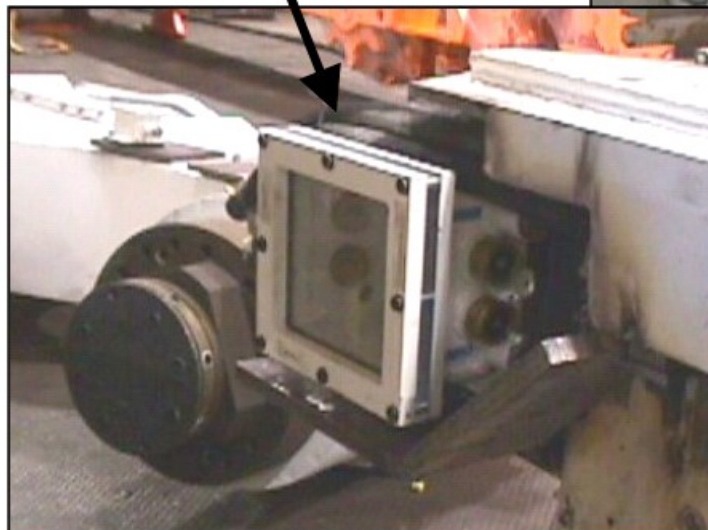
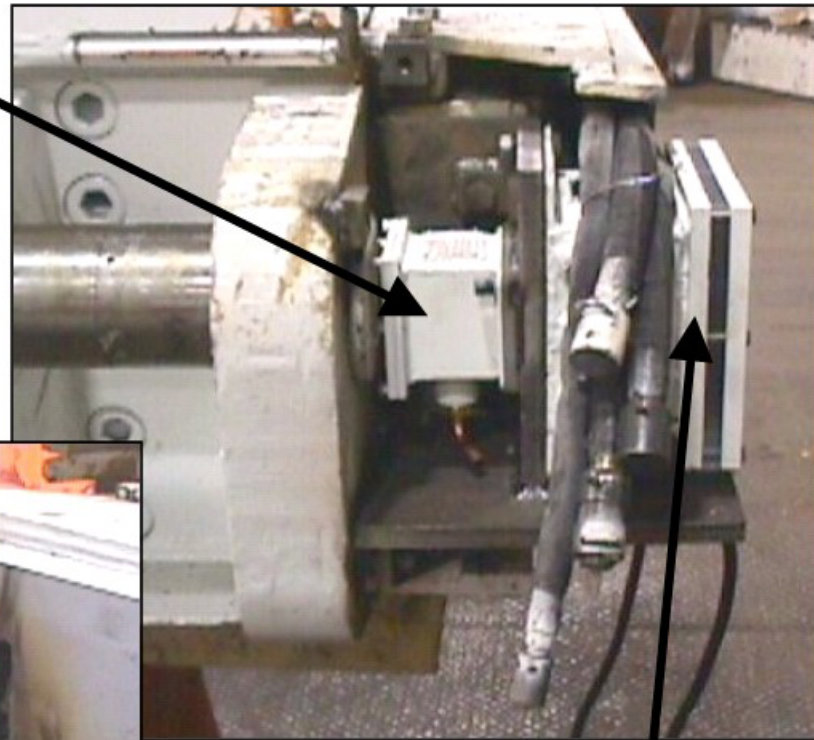


# Results and Discussion

Ohio Valley Coal Company  
7LS Shearer Install

CBI-3001  
(Inclinometer X/P)  
Bolted in Place

Display View  
from Operator  
Perspective



HGU-3001  
(Graphics Display X/P)  
Bolted in Place

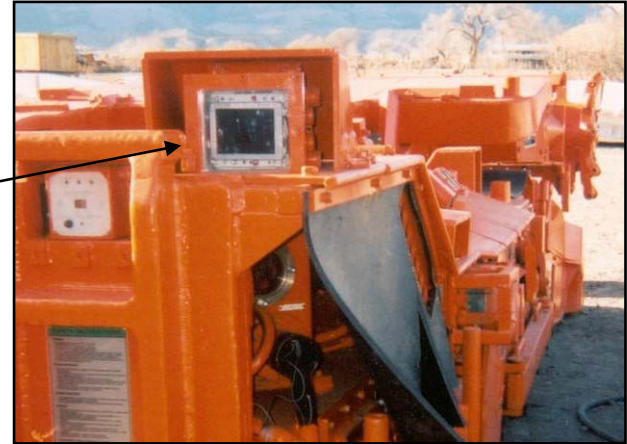




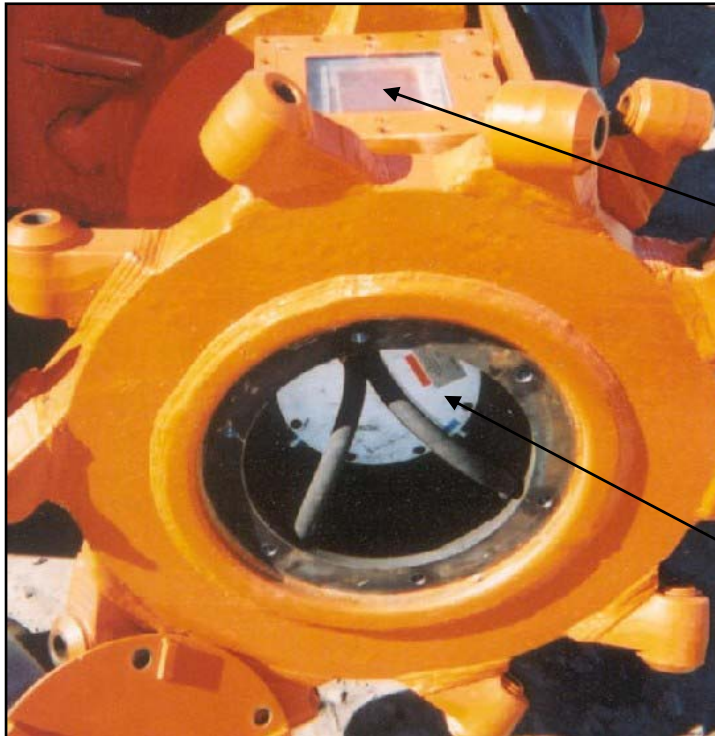
# Results and Discussion

West Elk Coal Company  
12CM-12 Install

HBU-3003  
Display Enclosure

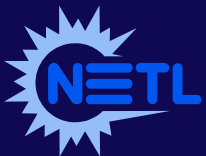


HSU-3002  
Sensor Enclosure



HPU-3001  
Generator Enclosure

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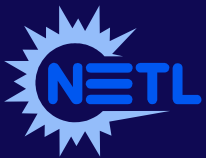
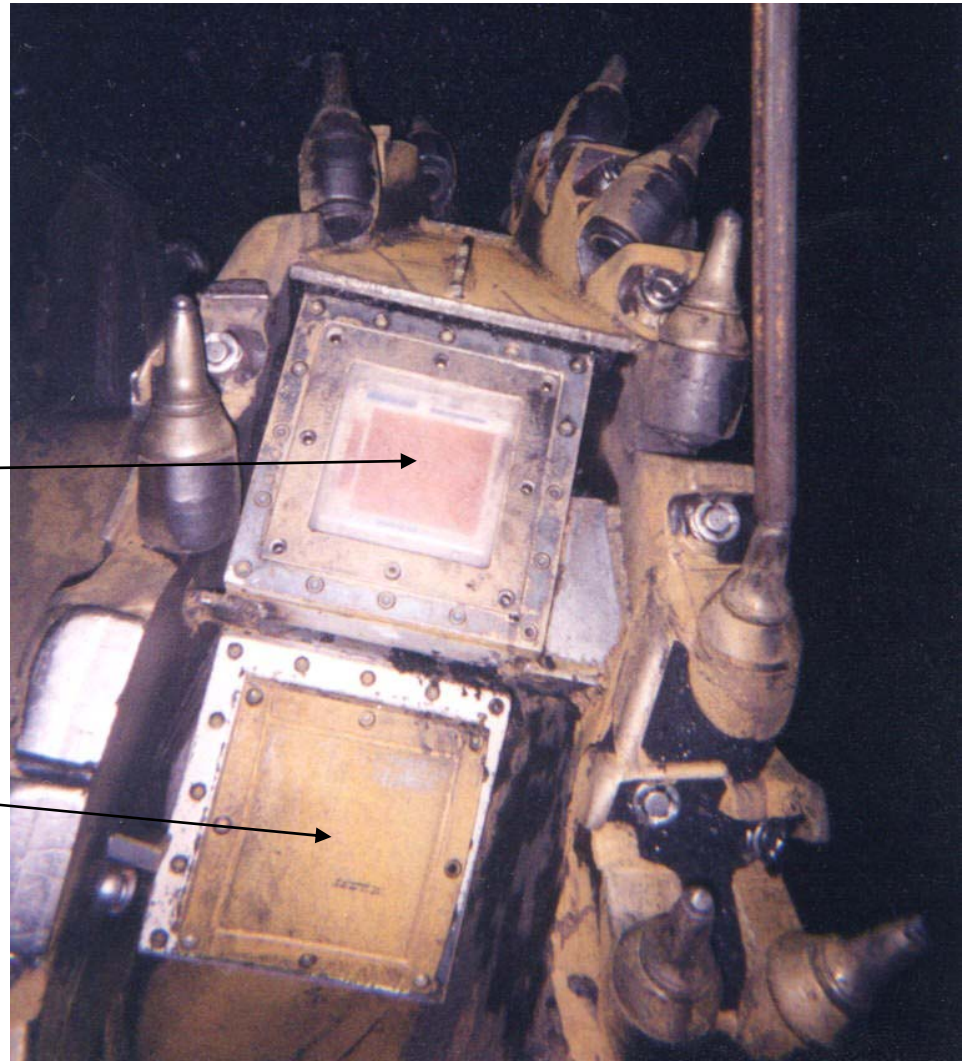


# Results and Discussion

Deserado Coal Mine  
4LS Shearer Install

HSU-3002  
Sensor Enclosure

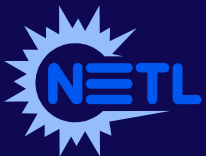
HBU-3001  
Battery Enclosure





# Results and Discussion

HS-Radar Development  
For Forward-Looking Void  
Detection Began in March with  
Laboratory Experimentation  
Using a 4'x6'x24' salt wall  
(coal seam simulation)

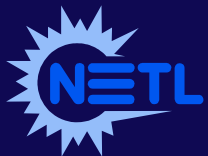
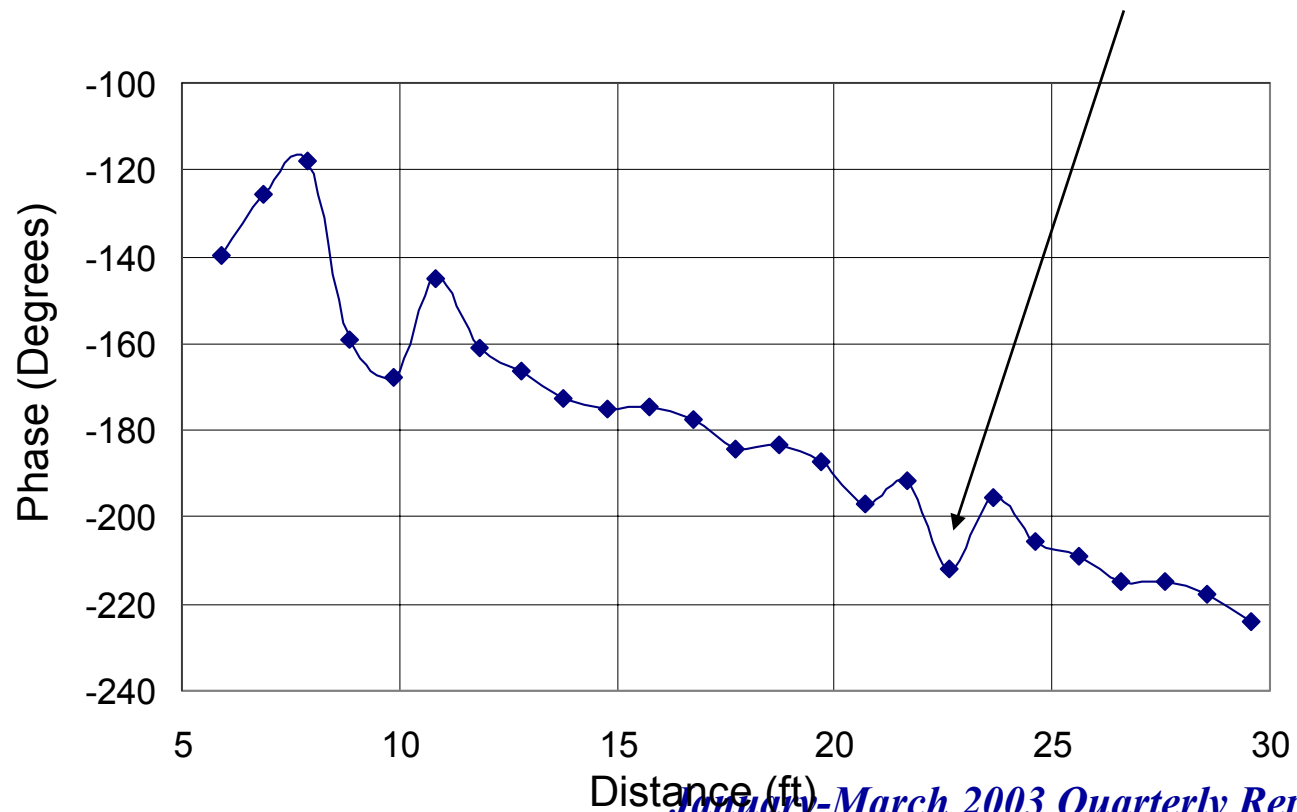


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# Results and Discussion

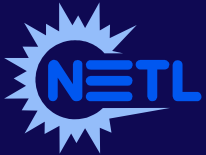
## HS-Radar Results

Salt Wall Void Reflection  
at 23 feet from HS-Radar



# Conclusions

- The HS physical assemblies are holding up very well to mining condition, impact/abrasion, and use from personnel. Parts have needed to be replaced to date due to normal usage, wear, or misuse
- The total tonnage, shifts, and operational hours are being documented at Monterey, Twentymile, FMC, Oxbow, Deserado, and West Elk
- A dual frequency sensor system has been developed to further the sensitivity, resolution, and depth of penetration of the HS
- An accelerometer based circuit has been developed to control the measurement triggering of the roof and floor. This has provided cleaner measurements and improved signal-to-noise ratios
- “Forward-looking” capabilities are being developed that will allow the HS (HS-RADAR) to detect anomalies in the coal seam ahead of mining, such as dikes, faults, and abandoned mine workings. The HS-RADAR prototype is being tested using a salt wall to simulate 25 feet of unmined coal seam



# Good News!

**During a recent HS-RADAR demonstration for an audience of MSHA technical representatives:**

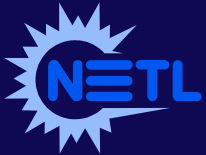
- A wall of salt was used to simulate a coal seam for HS-RADAR experiments
- Stolar successfully proved HS-RADAR could detect air voids through 23 feet of salt blocks
- The salt wall is considered a worse-case condition due to its block-like construction
- The HS-RADAR results were confirmed by MSHA's Kelvin Wu and George Gardner
- A test report will be available soon



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# Project Recognition

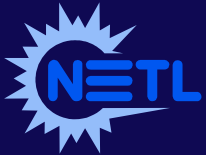
- “The Smart World of Mining”, World Coal Magazine, May 2001, p 51-54
- “Breakthrough Technology”, World Coal Magazine, May 2002, p 23-26
- “A Clearer Image”, World Coal Magazine, Vol. 11 No. 12, December 2002
- “Sensing the future”, World Coal Magazine, May 2002 *Release Pending*
- Recipient of the R&D 100 Award for breakthrough technologies from R&D Magazine



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# Comminution Circuit Optimization

- **Principal Investigator:** S. K. Kawatra, Michigan Technological University
- **NETL Project Manager:** David M. Hyman
- **Partners:**
  - Badger Mining Corp.
  - Cleveland Cliffs Iron Co.
  - J. M. Huber Corp.
- **Total Project Cost:** **\$1,067K**
  - DOE Share: \$ 449K
  - Participant Share: \$ 618K
- **Project Period:** 36 months
- **Project Start Date:** 12 Dec. 2000

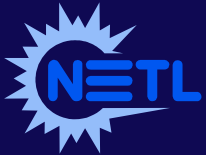


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# Project Objectives

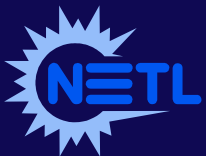
- To use comminution modeling to study methods for optimizing the product size distribution in order to minimize generation of excessively fine material by modeling alternative circuit arrangements
- Determine whether new technologies, such as high-pressure roll crushing, can be used to alter particle breakage behavior



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# Photo Library

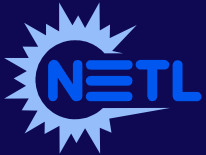


Low Profile Test Machine, six tests under different operating conditions were carried out on February 11<sup>th</sup>, at Buffalo, New York.

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# Photo Library



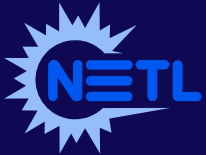
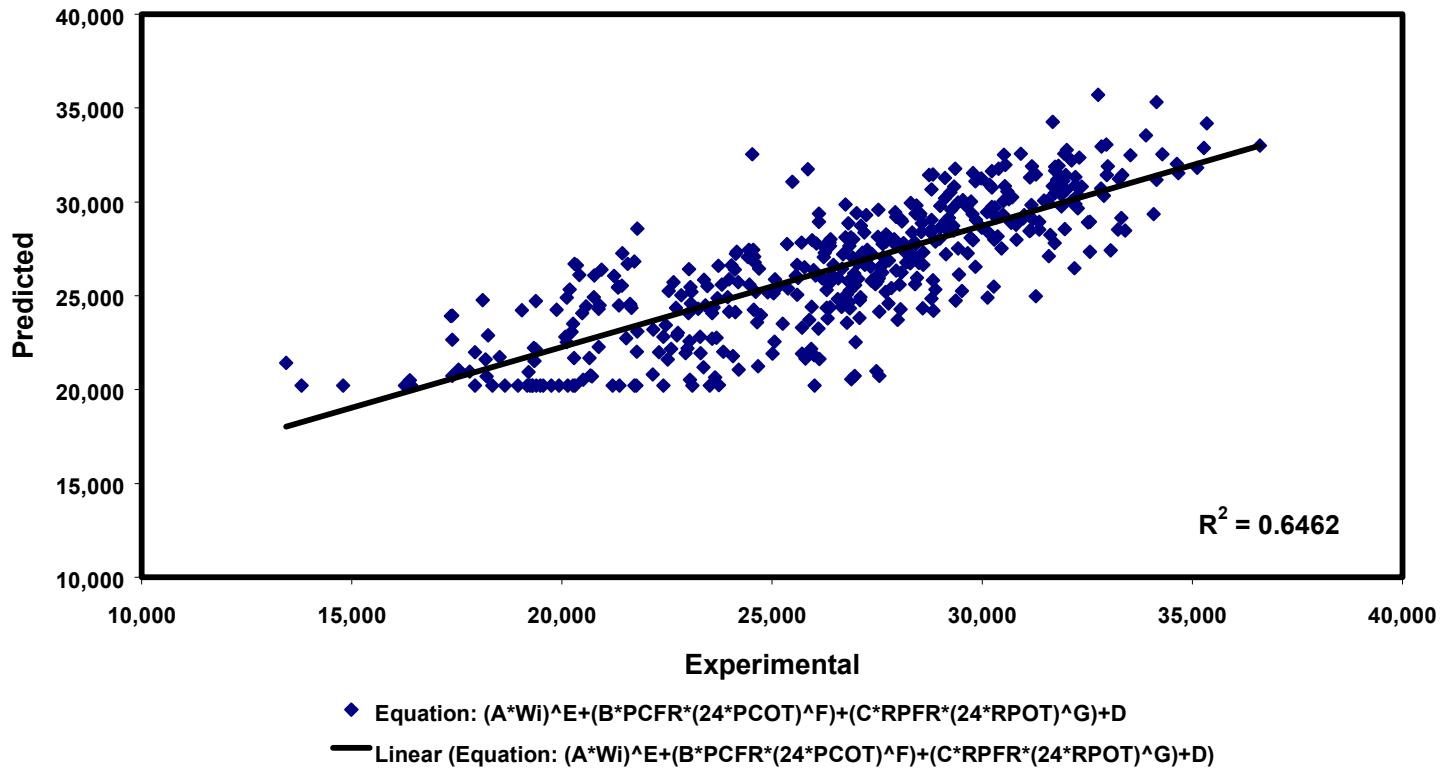
**Stack Sizer<sup>®</sup> Test Machine, six tests under different operating conditions were carried out on February 11<sup>th</sup>, at Buffalo, New York.**

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# Photo Library

Equation 3: Experimental vs. Predicted New Side Tons



Improved correlation between experimental and predicted plant feed rate. Plant feed rate was predicted using an equation based on work by [Furukawa, March 2003 Quarterly Report](#) operating time and feed rate.

# Milestones and Status

## Major Milestones Planned to Date/Status

### Planned Milestone

- Develop simulation models
- Optimization of throughput and efficiency
- Optimization of product size distribution
- Evaluation of advanced technologies
- Confirmation/optimization of circuits

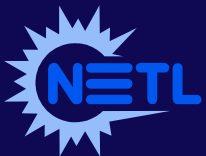
### Status

Dec. 01 (Completed)  
Dec. 02 (In progress)  
Dec. 02 (In progress)  
Nov. 03  
Dec. 03

Improved Mathematical relationships that predict plant through put based on work index and plant operating parameters.

Screen pilot plant scale test carried out for proposed circuit modifications, two different screening machines were tested.

Mathematical model for classification of 2-component mixture completed.



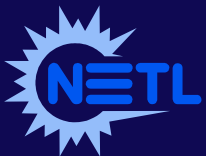
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# Milestones and Status

- **Key Decision Points Remaining**

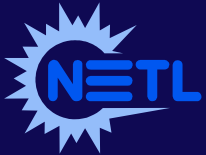
<i>Decision Point</i>	<i>Scheduled Date</i>	<i>Is it a go/no-go decision?</i>
<b>Circuit Simulation</b>	<b>01/2003</b>	<b><i>N</i></b>
<b>Advanced Technology Evaluation</b>	<b>08/2003</b>	<b><i>N</i></b>



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# Key Accomplishments

- **Progress to Date Highlights**
  - Circuit analysis using project results indicated that circuit efficiency and capacity could be improved by use of screening to take advantage of added primary grinding capacity provided by high-pressure grinding rolls.
  - Based on screen evaluation carried out on Feb. 11<sup>th</sup>, a plan was developed to use existing equipment available in the plant to carry out tests of the effects of introducing screening into the circuit.
  - Mathematical relationship to predict plant through put has been improved by modifying the proposed equation.
  - An improved hydrocyclone mathematical model, which was modified to account for the presence of both high-density and low-density particles, was successfully added to the USIMPAC modeling library for use in this project.

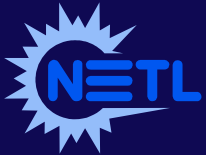


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# Good News!

- Laboratory hydrocyclone simulation can now account for the “fish-hook” behavior that is observed in the grinding circuit under study.
- Modified model used for hydrocyclone simulation shows improved results over previous models.
- Test work with screening machines showed that screens currently installed at the industrial partner plant can be retrofitted to run a plant scale test with a very low initial investment.
- Improved mathematical relationship was developed and used to predict plant throughput based on work index and equipment parameters.



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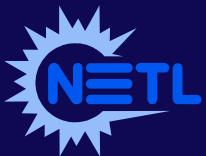
# Project Recognition

- H. J. Walqui, Mathematical Modeling of Coal Pulverizers using Population Balance Models, M.S. Thesis, Michigan Technological University, submitted August, 2001
- Walqui, H.J., Kawatra, S.K., Eisele, T.C., “Development of Mathematical Models for Coal Pulverizers”, Application of Computers and Operations Research in the Mineral Industry - Proceedings of the 30th International Symposium, Edited by Sukumar Bandopadhyay, Published by the Society for Mining, Metallurgy and Exploration, Inc. Chapter 10 Process Control and Optimization, pp 503 – 510.
- H. J. Walqui, T. C. Eisele, and S. K. Kawatra, “Development of Mathematical Models for Coal Pulverization”, Presented at the SME Annual Meeting, Phoenix, AZ, Feb. 25-27, 2002.
- H.J. Walqui, S.K. Kawatra, “Modelamiento Matemático de Circuitos de Comminución”, Presented at Infomina 2002, Lima, Perú, September 17-20.



# Commercialization Outlook

- Results of this project will be used to improve and optimize existing comminution circuits, and also to improve the design of future plants and expansions.
- Commercialization will begin with adoption of the developed techniques by the industrial co-sponsors immediately after the project is completed.
- Results will be disseminated to industry through short courses and publications in the technical literature.



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# DENSE MEDIA CYCLONE OPTIMIZATION

**Report Type:** Quarterly Technical Progress Report

**Reporting Period:** January 1, 2003 - March 31, 2003

**Principal Author:** Gerald H. Luttrell

**Submission Date:** April 15, 2003

**DOE Number:** DE-FC26-01NT41061

**NETL Manager:** David M. Hyman

**Submitting Organization:**

Department of Mining & Minerals Engineering

100 Holden Hall

Virginia Polytechnic Institute & State University

Blacksburg, VA 24061

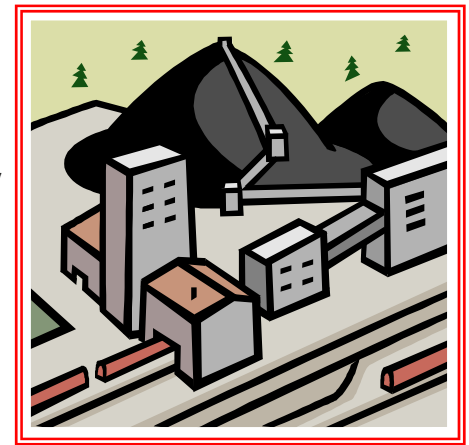
**Other Participants:**

Massey Coal Services

Partition Enterprises

Precision Testing Laboratories

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# Project Objective

- To develop engineering tools to improve HMC performance.
- These include:
  - Low cost density tracers to rapidly assess HMC efficiency (used by plant engineers)
  - Process models to predict influence of operating and design variables (used by plant designers)
  - Model-based expert system to provide a user-friendly interface for trouble-shooting HMC problems (used by equipment operators)



# Milestones and Status

- Baseline Assessment of performance successfully **completed** using density tracers and sampling campaigns.



Density tracers collected from a HMC evaluation.





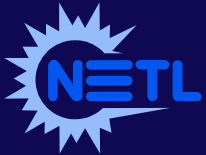
# Milestones and Status

- Baseline Assessment of performance successfully **completed** using density tracers and sampling campaigns.
- Follow-Up Assessments **completed** on to track improvements in circuit performance.



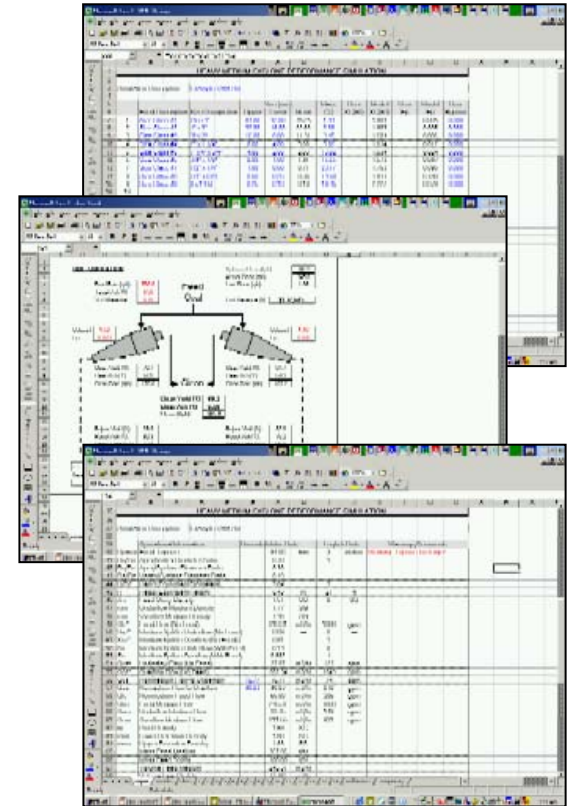
Collection of HMC samples for follow-up assessments.

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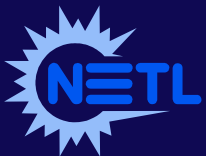
## Milestones and Status

- Baseline Assessment of performance successfully **completed** using density tracers and sampling campaigns.
- Follow-Up Assessments **completed** on a monthly basis to track improvements in circuit performance.
- HMC Process Simulator **completed** using a spreadsheet based format.



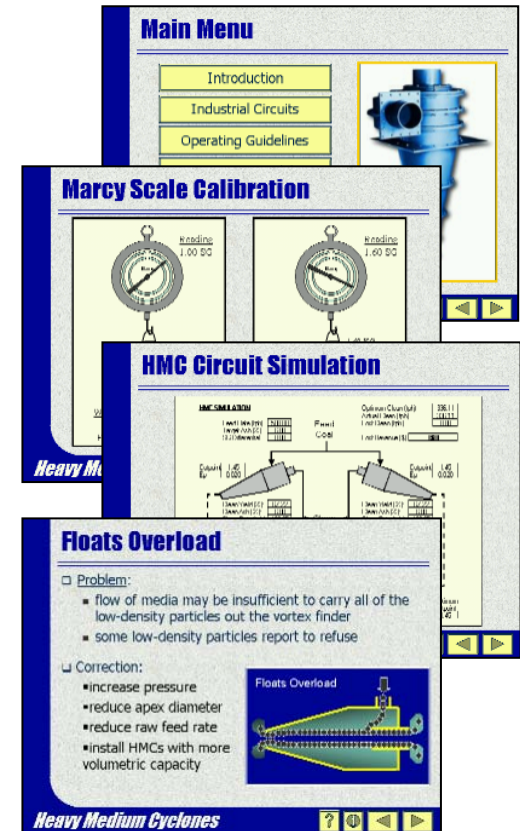
Sample input/output for the  
HMC simulation program.

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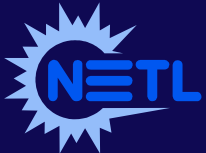


# Milestones and Status

- Baseline Assessment of performance successfully **completed** using density tracers and sampling campaigns.
- Follow-Up Assessments **completed** on a monthly basis to track improvements in circuit performance.
- HMC Process Simulator **completed** using a spreadsheet based format.
- HMC Expert System **completed** for plant training and trouble-shooting.

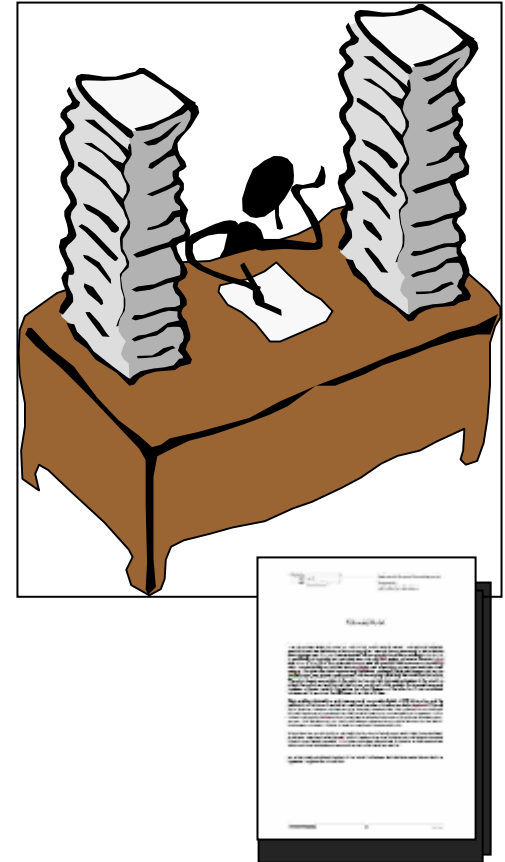


Sample pages from the HMC expert system.



# Milestones and Status

- Baseline Assessment of performance successfully **completed** using density tracers and sampling campaigns.
- Follow-Up Assessments **completed** on a monthly basis to track improvements in circuit performance.
- HMC Process Simulator **completed** using a spreadsheet based format.
- HMC Expert System **completed** for plant training and trouble-shooting.
- Final Project Report currently being **prepared**.
- Cost-Sharing Documentation currently being **finalized**.

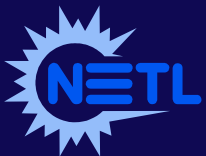
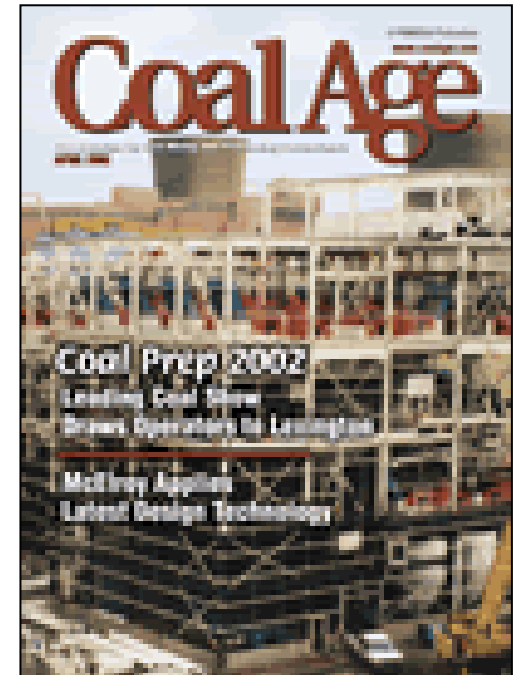


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# Project Recognition



- **Coal Age Magazine**
  - Guidelines developed from project to be featured in the upcoming issue of “Coal Age” magazine.
  - Serves as the leading trade journal for the coal preparation and mining (circulation of  $\approx 10,000$  subscribers).
  - Article entitled “*Operating Guidelines for Heavy Medium Cyclone Circuits*”
  - Article recognizes financial support provided by the U.S. Department of Energy

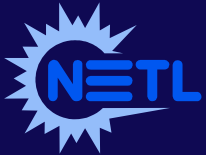
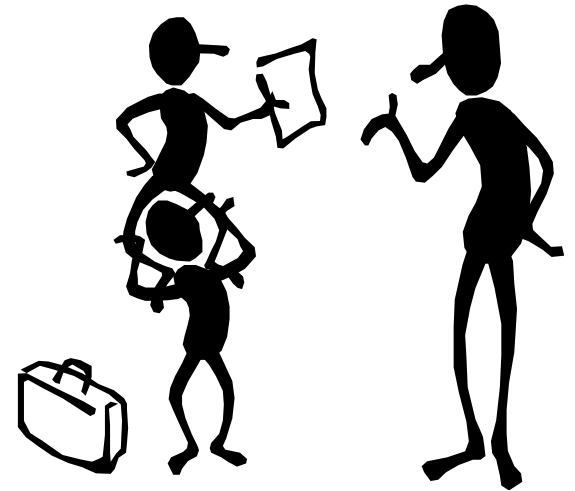


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# Commercialization Outlook

- Technology already in the field...
  - Tracer services now provided by Precision Testing Laboratories (PTL) of Beckley, WV.
  - Financial returns already realized from tracer tests conducted by PTL for Turris Coal Company.
- New website developed to distribute project data...
  - Available under [www.coalprep.org](http://www.coalprep.org)
  - Used to distribute project status and technical reports
  - Soon to be used to distribute project software (activated upon approval of final technical report)

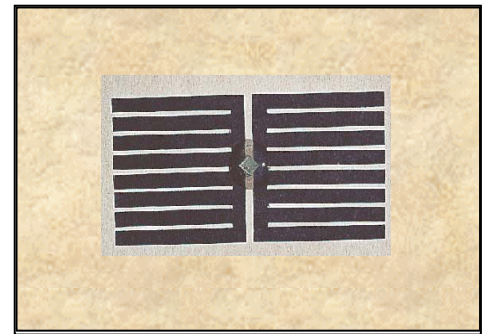
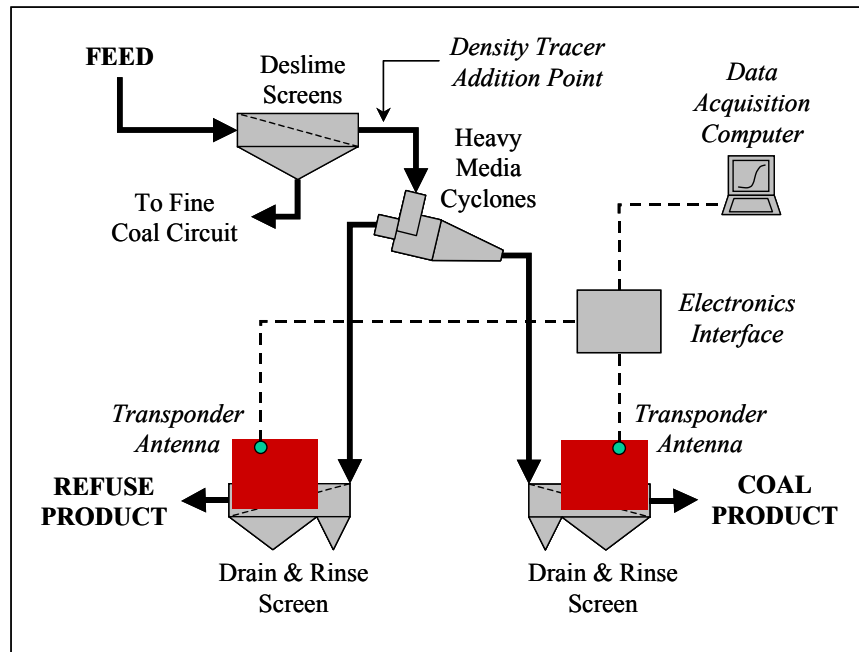


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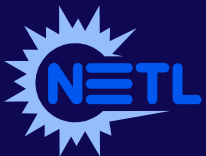


# Commercialization Outlook

- **Project data used to develop new spin-off project.**
  - Involves development of “electronic transponder” tracers that can be automatically detected with minimal personnel.
  - Funded by Center for Advanced Separation Technologies

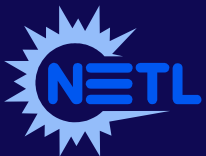


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# Development of Novel Dewatering Aids for Minerals and Coal Fines

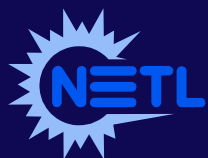
- **Principal Investigator:** R.-H. Yoon, Minerals and Coal Technologies, Inc.
- **NETL Project Manager:** David M. Hyman
- **Partners:**
  - Peterson Filters Corp.
  - Beard Technology
  - Boliden Minerals, AB
  - Ondeo Nalco
- **Total Project Cost:** **\$624K**
  - DOE Share: \$ 312K
  - Participant Share: \$ 312K
- **Project Period:** **33 months**
- **Project Start Date:** **15 March 2001**



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# Project Objectives

- To develop novel chemicals that can facilitate the removal of water using conventional mechanical dewatering devices:
  - Vacuum filters
  - Pressure filters



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# Milestones and Status

## Major Milestones Planned to Date/Status

<u>Planned Milestones</u>	<u>Scheduled</u>	<u>% Completed</u>
<b>Task 1: Surface Chemistry Control</b>	<b>03/03</b>	<b>75</b>
1. Reagent Development for Minerals	08/02	90
2. Surface Tension & Contact angle	10/02	85
3. Reagent synthesis	11/02	75
4. Auxiliary reagents	02/03	65
5. Reagent Blends	03/03	65
6. Conditioning	03/02	75
7. Mode of Addition	05/02	65
<b>Task 2: Capillary Radius Control</b>	<b>03/03</b>	<b>70</b>

### Key Decision Points Remaining

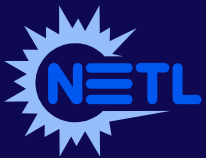
- Reagent dosage
- Water chemistry



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# Key Accomplishments

- **Importance of water chemistry has been recognized.**
  - Simple methods of overcoming this problem is explored.
- **Patents:**
  - One U.S. Patent has been issued during the past quarter.



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# A Real-Time Coal Content/Ore Grade Sensor

**Principal Investigator:** R. Swanson, Resonon, Inc. and T. Moon, Montana Tech

**NETL Project Manager:** David M. Hyman

**Partners:** Montana Tech of the University of Montana; Stillwater Mining Co.; Western Energy Company, A Westmoreland Mining Company; Montana Board of Research Commercialization **Technology**

**Additional Contributions:** Barretts Minerals, Inc. (Talc); TIMET, Inc. (Titanium Sponge); MSU TechLink (Outreach and grants)

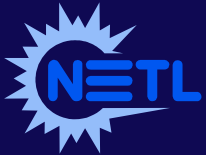
*January-March 2003 Quarterly Report*





# Budget

- **Total Project Cost:** **\$717K**
  - DOE Share: \$358K
  - Participant Share: \$359K
- **Project Period: 36 months**
- **Project Start Date: 21 June 2001**

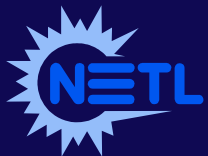


# Project Objective

- To develop machine vision systems capable of grading coal, platinum/palladium, or other ores in real time. An additional objective is to fabricate instrumentation in a small and rugged package that can be used for on-site, real-time measurements.

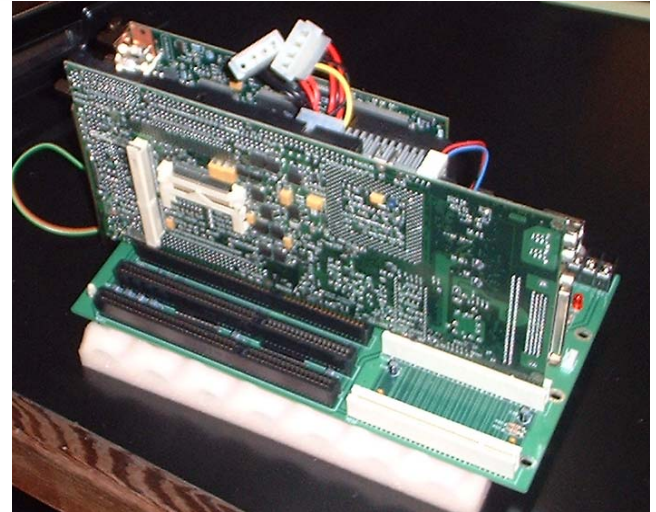


**Reconstructed Color Image  
of coal sample with pyrite**

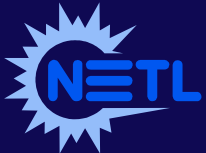


# Photo Library I

**A board-level computer and pc/104 computer system are shown. Incorporating these instruments to the machine vision system will decrease size and increase speed. Currently, the board-level computer (top image) performs all the critical system functions.**



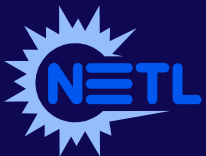
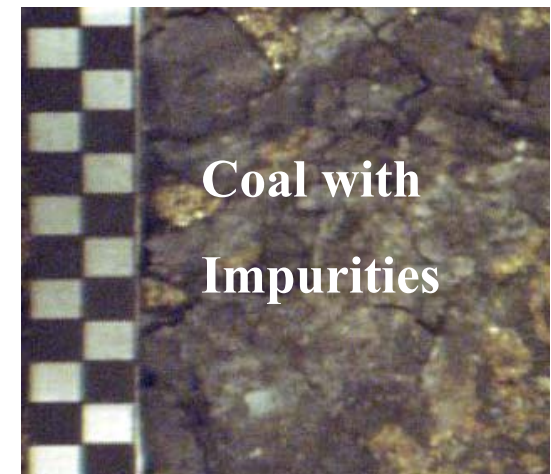
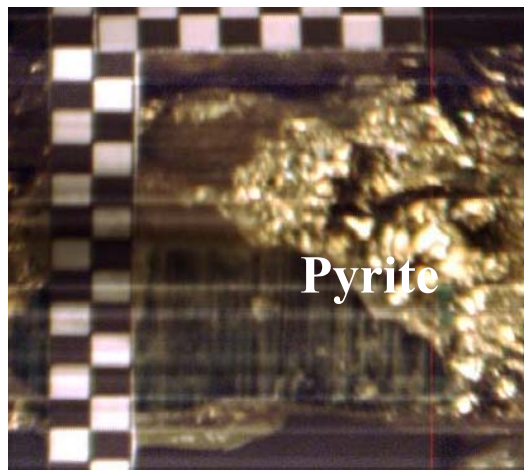
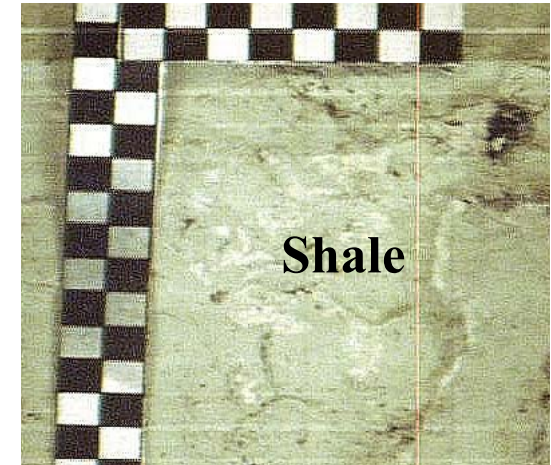
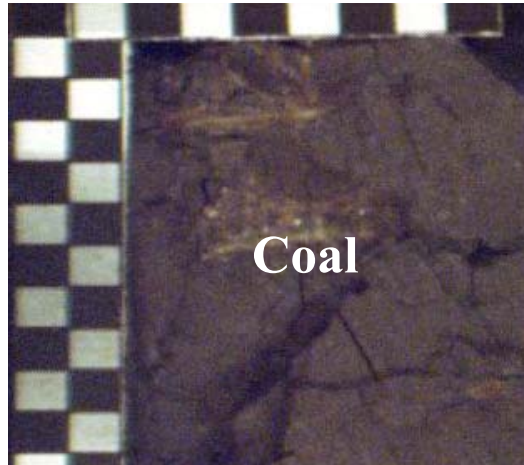
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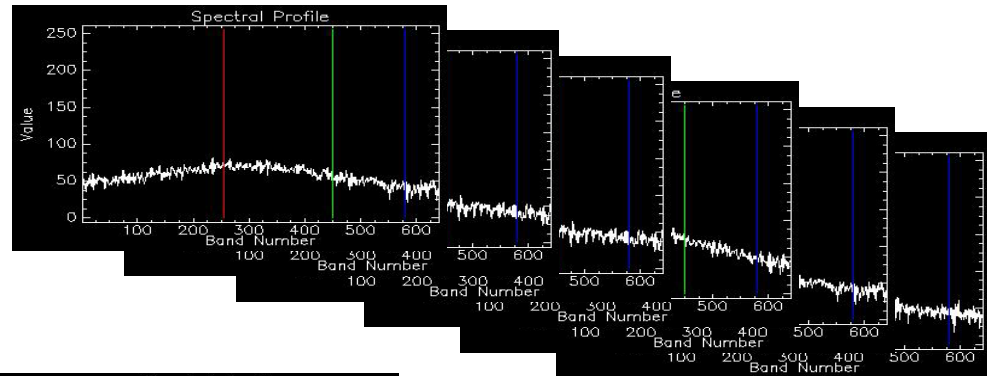
# Photo Library II

The three key constituents in our coal samples are coal, shale, and pyrite. As one would expect, the brightness and colors of these three materials are very different.

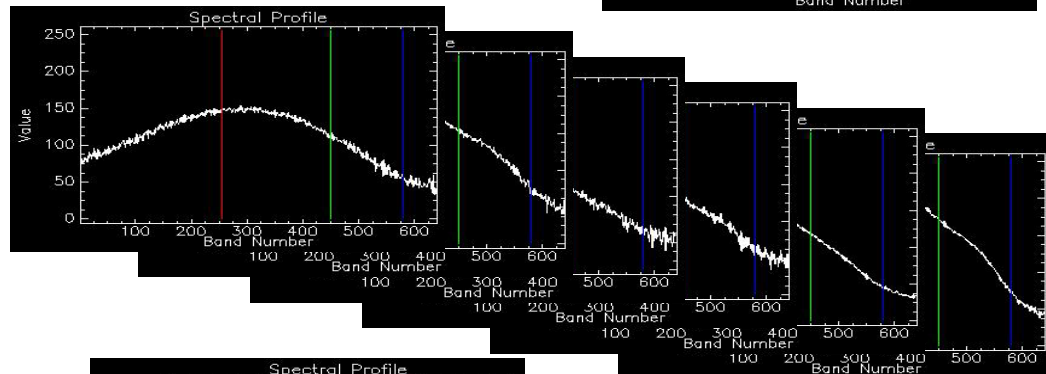
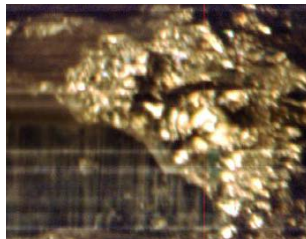


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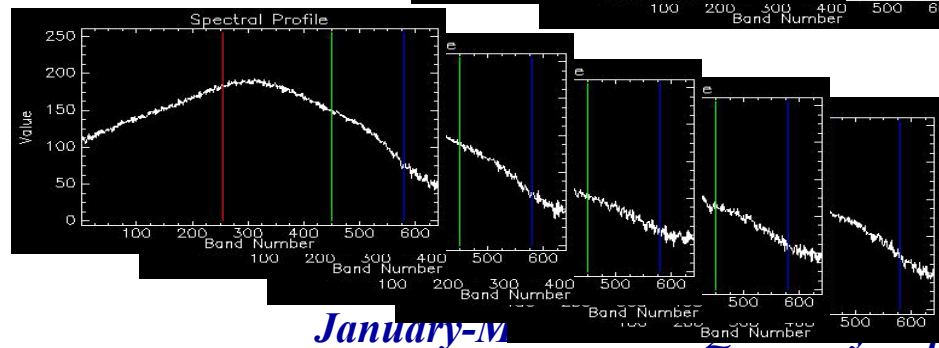
# Photo Library III



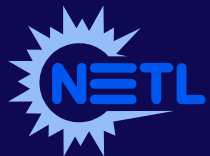
Coal



Pyrite



Shale



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Spectra from coal, pyrite, and shale within the samples.

# Progress This Quarter

## Software Developments:

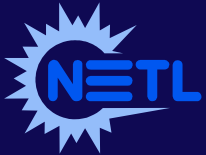
Considerable progress has been made incorporating ORASIS software from the Naval Research Labs into the machine vision system. This greatly reduces the time required to analyze data

## Hardware Developments:

A board-level computer has been assembled and used for the machine vision system. This will enable deployment of the technology to more harsh environments and decrease the size of the instrumentation. Ongoing work with pc/104 computers may lead to an even smaller footprint.

## Coal analysis:

Coal samples and typical impurities have been imaged and classified. As expected, these objects are easily distinguished.



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# Milestones and Status

## Year 2 Tasks and Status:

### **Task 1: Identify Applications and Study Particle Size Effects**

Status: Progress is going well with coal studies. Work with Pt/Pd ore samples is complete and has been shown to work well. However, a down-hole instrument is required to be useful. Defect detection in titanium sponge went well, but the potential end user is currently considering simpler technology.

### **Task 2: Design Sensor**

Status: The optical system is complete and works well. Work with board-level computers to decrease the footprint is nearly complete. A firewire interface system is being developed, which will provide plug-and-play capabilities.



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# Milestones and Status

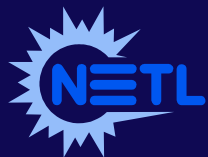
## Year 2 Tasks and Status:

### **Task 3: Manufacture Sensor**

Status: First- and Second-generation sensors have been developed and perform well. A system similar to what was developed here has been sold to the University of Minnesota.

### **Task 4: Test Sensor**

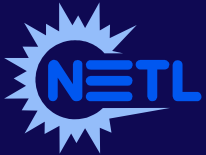
Status: The sensor works well and has been tested with Pt/Pd ore, titanium sponge, and coal. Processing time has been greatly decreased by incorporating Naval Research Labs software. Ongoing efforts are devoted to licensing this software.



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# Key Accomplishments

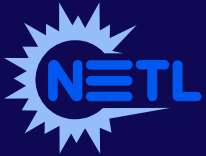
- **Highlights of Progress to Date**
  - The imaging spectrometer work well and is easy to use.
  - This work has led to a Master's Thesis and a publication.
  - The Center for Biofilm Engineering at Montana State University is interested in testing the imaging spectrometer for stream health monitoring applications.



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# Good News!

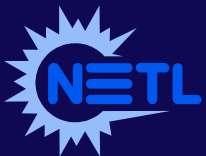
- A machine vision instrument similar to the hyperspectral imager used for this project has been ordered by the University of Minnesota.
- Montana Tech has contributed funds for a new coal analyzer to support this effort. This instrument will provide independent assays, which will provide “ground truthing.”
- Researchers at Montana Tech are writing new proposals based on results of this effort to expand the technology capabilities and range of applications.



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# Project Recognition

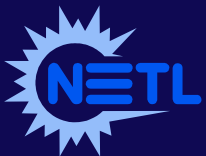
- Posters on this effort were presented in the rotunda of the state capital building and at the Montana Academy of Sciences spring conference.
- This work has resulted in a Masters Thesis.
- Results from this effort will be published in Geophysics.



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# Wireless Mine - Wide Telecommunications Technology

- **Principal Investigator:** Steve Meiksin - Transtek
- **NETL Project Manager:** Morgan Mosser
- **Partners:** University of Pittsburgh, Victor Products USA, National Institute for Occupational Safety and Health, CONSOL Inc., Gateway Commerce Center
- **Total Project Cost:** **\$1,075,800**
  - DOE Share: \$400,000
  - Participant Share: \$675,800
- **Project Period:** **36 months**
- **Project Start Date:** **Feb. 7, 2001**

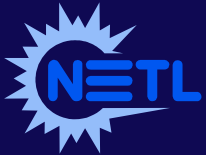


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# Project Objectives

- **Development of two-way, real-time, wireless communications system for use in underground mines. This technology will lower the cost of mining by increasing productivity as well as increasing the safety of miners**

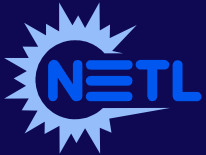


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# Transtek's Remote Interface



A comprehensive wireless mining communications system that will allow two-way communications among underground personnel and between underground and surface personnel will be designed and tested



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# Milestones and Status

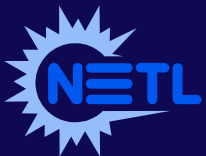
## Major Milestones Planned to Date/Status

### Planned Milestones

### Scheduled

### Completed

- |  |       |             |
|--|-------|-------------|
| – Develop in-mine voice capability                 | 12/01 | 12/01       |
| – Expand the through-the-earth voice technology    | 12/01 | 12/01       |
| – Develop the digital data transmission capability | 12/02 | 12/02       |
| – Develop tracking sensors and beacons             | 12/03 | in progress |
| – Test the wireless telecommunications system      | 12/03 |             |



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# Key Accomplishments

- **Project Highlights**

- A surface-mount electronic circuit to pre-process voice signal before injections into the power line for the in-mine communications system was designed and fabricated onto a printed circuit
- A continuously self-adjusting signal transmission mechanism for through the earth communications was conceptualized and designed. This mechanism will ensure peak quality voice and data transmission at all times
- Excessive interference in overlapping areas was eliminated

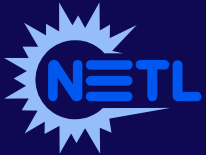


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# Key Accomplishments

- **Project Highlights (cont'd)**

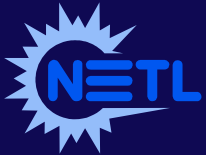
- An evaluation of technologies lead to the decision to use adaptive spread spectrum synchronization and modulation to interface the in-mine system with power lines
- A special purpose advanced technology filter to reject noise for through the earth communication was designed and implemented successfully
- Signal compression in preparation for multi-channel communication through power lines was successfully completed
- Noise-free through the earth voice communication was demonstrated



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# Key Accomplishments

- **Project Highlights (cont'd)**
  - The through-the-earth wireless voice communications lab prototype was finalized and repackaged to construct a commercial/industrial demonstration prototype. Features were added to the system to make a two-way conversation possible using three different man/machine interfaces. This accommodates potential users' preferences depending on their particular environments.

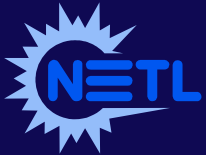


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# Key Accomplishments

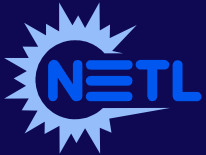
- **Project Highlights (cont'd)**
  - Arrangements were made with NIOSH to install our through-the-earth and in-mine wireless communications system in NIOSH's Lake Lynn underground mine for evaluation and demonstration to potential users. The two systems will be linked to allow persons inside the mine to communicate with two-way radios with other persons anywhere in the mine as well as with persons on the surface. Representatives of CONSOL and other companies will be invited early in 2002 to see the system in operation



# Key Accomplishments

- **Project Highlights (cont'd)**

- Our subsystem for voice compression was combined with the adaptive spread spectrum synchronization and modulation subsystem for interfacing with power lines
- Using this combination by a factor of 12, compressed voice was transmitted through a power line, expanded at the receiving end, and received with high clarity
- Transtek's communication system was installed in NIOSH's Lake Lynn mine for use in rescuer training scheduled for April 2002
- Point-to-point data communication was added to the in-mine system
- The USPTO issued Transtek a patent for its in-mine technology
- A "SPEED" - Shutdown Prevention through Early Error Detection – circuit was added to the in-mine system to facilitate system installation and initial adjustments

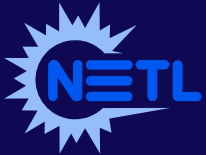


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# Key Accomplishments

## •Project Highlights (cont'd)

- Data transmission was added to the through-the-earth and the in-mine systems.
- A feature was added to the in-mine system that allows to dial a particular person rather than alerting everybody at once.
- Transtek sold additional systems bringing the total number of underground mine installations to five.



# Milestones and Status

## Key Decision Points Remaining

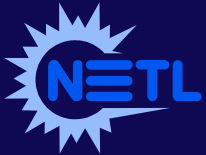
Decision Point	Scheduled Date	Go/no go
Complete voice communication capability	12/01	Completed
Develop digital communication capability	12/02	Completed
Develop tracking sensors and beacons	12/03	In Progress



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# Good News!

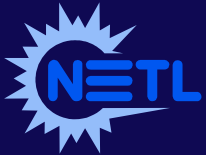
- A continuously self-adjusting signal transmission mechanism for through the earth communications was conceptualized and designed. Excessive interference in overlapping areas was eliminated
- A special purpose advanced technology filter that was designed and implemented into prototype equipment has proven to make possible noise-free through the earth voice communication



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# Good News!

- A commercial through-the-earth wireless voice communications prototype was built and will be installed in NIOSH's Lake Lynn underground mine for testing and demonstration in early 2002. The system will be linked with Transtek's in-mine wireless communications system allowing persons in the mine to talk to other persons anywhere in the mine as well as to persons on the surface.
- Transtek's wireless communication system was installed in NIOSH's Lake Lynn mine for use in rescuers' training scheduled for April 2002.





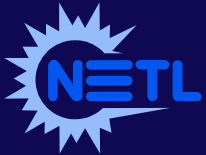
# Good News

**Transtek received favorable critic for its system from attendees at the mining training program at NIOSH's Lake Lynn mine in April 2002. A report will be issued by NIOSH.**

**Transtek was issued a U.S. patent for its in-mine System.**

**Transtek received inquiries for the use of its in-mine system in aboveground, other than mining, applications in addition to mining applications.**

**Transtek has sold and installed five wireless communication systems in underground mines.**



# Project Recognition

A press release introducing our cat-5 ComCell wireless in-mine communications system appeared in several mining journals. The press release also introduces the Through-the-Earth (TTE) wireless communications system as being under development.

Transtek's system was highlighted in a feature article titled "Making the Connection" published in the March 2001 issue of the Engineering & Mining Journal (E&MJ).

Transtek's systems were included in a paper presented by Ronald S. Conti of NIOSH at The Northwest Mining Association's 107th Annual Meeting, Dec 3-7, 2001.

Transtek was issued a U.S. patent for its in-mine system.

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# Commercialization Outlook

- Transtek is partnered with Victor Products USA for marketing and selling Transtek's present products. Transtek plans to expand this relationship to include the new products that are now under development.
- Transtek added a sales/marketing person to its team.
- The voice communication capability will be brought to market early in 2002.

The data communication capability including environmental and production sensor monitoring and control will be brought to market in 2003.

- Tracking people and equipment will be brought to market in 2004.



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# Commercialization Outlook

- Transtek is exploring marketing contacts in China.
- Transtek is exploring application of its system to aboveground environments in addition to mining environments.
- Transtek has sold and installed five wireless communication systems in underground mines.



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# Treatment of Cyanide Solutions and Slurries Using Air-Sparged Hydrocyclone (ASH) Technology

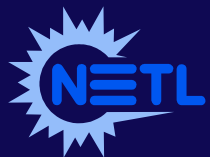
- **Principal Investigator:** Jan Miller, University of Utah
- **NETL Project Manager:** Morgan Mosser
- **Partners:** Baker Process, CWT Inc., Doug Halbe consultant, Dawson Metallurgical, Normandy Mining Inc., Placer Dome, Solvay, Elbow Creek Engineering, Kennecott Minerals, Newmont Gold, Earthworks, Cherokee Chemicals
- **Total Project Cost:** **\$644,551**
  - DOE Share: \$319,351
  - Participant Share: \$325,200
- **Project Period:** **24 months (+ 3 month extension)**
- **Project Start Date:** **April 1, 2001**



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# Project Objectives

- **Development of technology for cyanide recovery and destruction using an Air Sparged Hydrocyclone (ASH). Process waters will be tested. The first year objectives of the research will be to develop the technology and evaluate various process parameters, safety issues, and flow sheet for installation at plant operations.**
- **Based upon the investigation in this phase the plant trial will be initiated in the second year.**



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# Milestones and Status

## Major Milestones Planned to Date/Status

<u>Planned Milestones</u>	<u>Scheduled</u>	<u>Completed</u>
– Design Pilot Plant based on Lab Testing	02/2002	04/2002
– Assemble and Install Pilot Plant	03/2002	06/2002
– Complete 1st & 2nd Stage Pilot Field-Tests	11/2002	11/2002
– Complete 3 <sup>rd</sup> Stage Pilot Field Test	05/2003	
– Complete Cost & Market Analysis	05/2003	
– Final Report	06/2003	



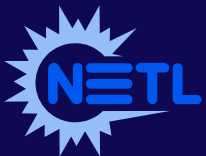
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# Milestones and Status

- **Key Decision Points Remaining**

- Assess any flaws that would justify halting the tests
- With respect to the cyanide destruction work

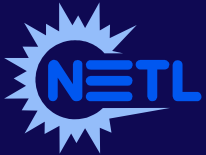
<i>Decision Point</i>	<i>Scheduled Date</i>	<i>Is it a go/no-go decision?</i>
<i>Assess any fatal flaws that would justify halting the tests</i>	<i>Month/Year Aug. 2001</i>	<b>Go</b>
<i>With respect to the cyanide destruction work</i>	<i>Month/Year Nov. 2001</i>	<b>Go</b>



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# Key Accomplishments

- Mobile ASH Pilot Plant was received at the University of Utah and completely redesigned and upgraded.
- Health & Safety Plan has been prepared and implemented.
- Safety Equipment and Supplies selected, procured & installed.
- Laboratory Tests to establish conditions for free Cyanide removal have been completed.
- Analytical procedures implemented.
- Presentations were made at three conferences.
- Submissions for two other conferences were made.
- Pilot Plant tests were performed at the University of Utah.
- First Phase Pilot Plant tests performed at Midas Mill.
- Second Pilot Plant tests were completed at Midas Mill, and new design of absorbing ASH successfully implemented
- Redesign and Modification of stripping portion ASH System



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# Field Test

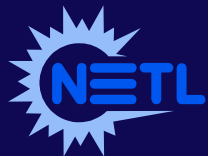
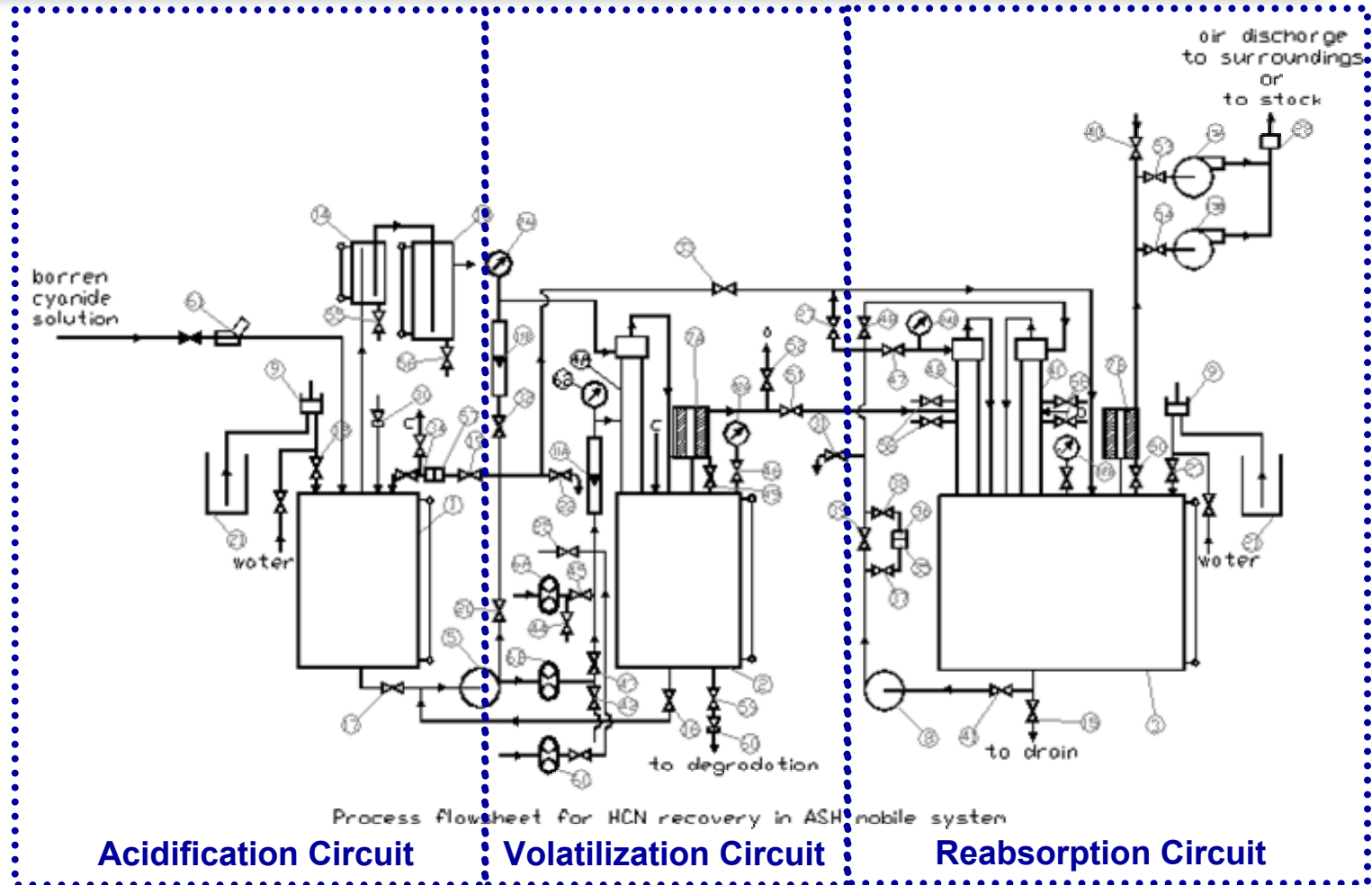


**ASH Unit during the field test in Midas – November 2002**

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# Mobile ASH System Flow Diagram



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# Project Recognition

- Presented paper at the Mining Showcase in Salt Lake City, UT in Aug 2001
- Presented paper at the 2002 SME Annual Meeting in Phoenix, AZ in February 2002
- Presented paper at the XXXIX Symposium on Physicochemical Problems of Mineral Processing in Polanica Zdroj, Poland in September 2002
- Preparing submissions for two other conferences
- Three additional mining and service companies are participating as partners
- Opportunities for using the ASH in mill and heap closures are being explored

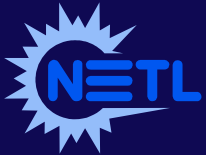


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# Good News!

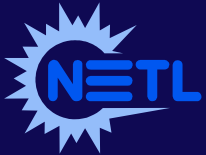
- A mobile system has been constructed for efficient recovery of HCN from cyanide-barren process waters.
- ASH represents compact and efficient stripper and absorber.
- ASH proved to function properly under vacuum.
- The mobile system operates during each run under vacuum therefore is inherently safe in the workplace.
- Air pressure drop in redesigned absorbing ASH is less than 1" of water which is a pre-condition for recirculation of the gas phase in the system (no HCN release to the atmosphere).



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# Computerized Roof Bolt System

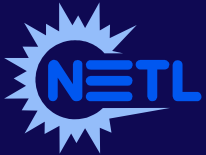
- **Principal Investigator:** Syd Peng, West Virginia University
- **NETL Project Manager:** Morgan Mosser
- **Partners:** CONSOL Inc., Commercial Stone Co. Inc., Ohio Valley Coal Co., J.H. Fletcher & Co., Newmont Mining Co., Riverton Coal Production Inc.
- **Total Project Cost:** **\$1,352,338**
  - DOE Share: \$563,504
  - Participant Share: \$788,834
- **Project Period:** 36 months
- **Project Start Date:** Dec. 18, 2000



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# Project Objectives

- Development of a computerized method to evaluate the roof geology and stability in real-time during roof bolting operations
- Roof bolt system design requirements will be developed. The real time evaluation of roof geology and stability conditions as well as design requirements for roof bolting systems will reduce roof falls
- The results will be used to develop a computer program that will work with the bolter for real time production of the mechanical properties, structures of roof strata and design requirements for roof bolt systems

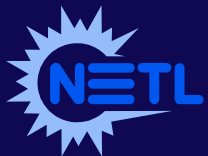


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# Milestones and Status

## Major Milestones Planned to Date/Status

<i>Planned Milestone</i>	<i>Scheduled</i>	<i>Completed</i>
Development of operator control technology	09/01/01	completed
Laboratory and underground testing	12/31/01	90% completed
Drilling parameter data analysis and correlation	10/01/03	75% completed
Software development for mapping of roof conditions.	10/01/03	continuing
Computer modeling to investigate the mechanisms	10/01/03	70% completed
Development of computerized bolting design system	10/01/03	50% completed

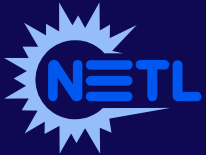


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# Key Accomplishments

- **Project Highlights**

- Additional tests have been performed at Marrowbone mine. Problem with of the positioning sensors have been fixed. The bolter has been moved to Massey Black Knight II Mine for field testing.
- Development of the systematic and mechanics-based approach for interpreting the drilling parameters is continuing. In order to minimize the problems of data fluctuations, a new trendline method has been developed and will be incorporated with the original approach to make the data interpretation more reliable.
- Methods using the drilling hardness and hydraulic drilling power approaches to locate the rock interfaces and fractures are being developed. The logics for computer programming have also been developed and tested with the collected data. It is expected that a methodology to combine all the methods for identifying the interfaces and fractures will be adopted.

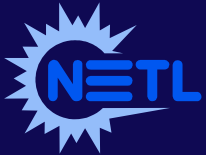


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# Key Accomplishments

- **Project Highlights (cont'd)**

- Three-Dimensional finite element models for simulating the tensioned bolt have been developed. Two-Dimensional finite element models for simulating the fully grouted resin bolts have also been developed. The effects of sliding and separation of bedding planes have been considered in these models.
- Based on the numerical modeling results, the design criteria for tensioned and fully grouted resin bolts are being developed. The yielding zone developed over the entry can be used to determine the bolt length, the magnitude of plastic strain can be used to judge the roof local stability, and the stress distribution around the entry and bolt load are also used to check roof stability.

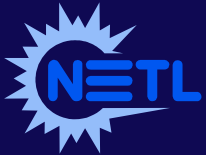


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# Key Accomplishments

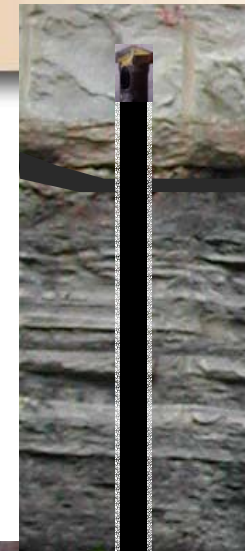
- **Project Highlights (cont'd)**
  - The development of a real-time roof geology mapping and bolt design program is well under way. This program is currently able to
    - Considerably reduce the amount of work involved in data processing.
    - The drilling power and hardness approaches have been built in the program. The methods to identify rock interface and fractures have also been programmed.
    - The program is able to display and store and acquired drilling parameter data and the interpretation results.
    - Using the roof geology information, the suitability of the current roof bolting design will be assessed.



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# Roof Bolting - Computerized Roof Bolt Design System

Development of a computerized method to evaluate the roof geology and stability in real-time during roof bolting operations.



**Sandstone**

**Crack**

**Laminated  
Shale**

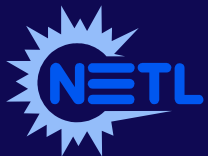
**Shale**



**Drill Control Unit**



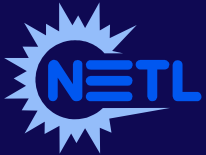
**Underground  
Testing**



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# Project Recognition

- **Technical Papers presented at 2003 SME Annual Meeting, Cincinnati, OH, Feb. 24-26, 2003**
  - “Tensioned Bolting Design”



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# Good News!

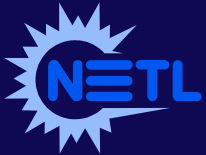
1. More field tests have been conducted in one underground mine. The strata features in the drilled holes have been examined with an improved scope system and procedure.
2. Development of a systematic approach for estimating rock strengths is continuing. Trendline method has been developed to make the data interpretation more reliable. New methods have been proposed to identify the rock interfaces and fractures/voids.
3. 2-D and 3-D models for modeling the fully-grouted resin and tensioned bolts have been developed, respectively. Capabilities of incorporating the bedding planes have been built in both models. Based on the simulation results, the design criteria for tensioned and fully grouted resin bolts are being developed.



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# 24-Channel Geophone Array for Horizontal or Vertical Boreholes

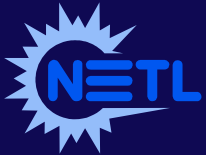
- **Principal Investigator:** E. Westman, Virginia Polytechnic Institute and State University
- **NETL Project Manager:** David M. Hyman
- **Partners:** CONSOL, Inc.; NSA Engineering Inc.
- **Total Project Cost:** \$273K
  - DOE Share: \$125K
  - Participant Share: \$148K
- **Project Period:** 33 months
- **Project Start Date:** 12 Dec. 2000



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# Project Objectives

- To develop a 24-channel array of seismic sensors capable of being mounted in a dry vertical or horizontal borehole in order to significantly increase the accuracy of tomographic imaging of conditions ahead of mining by allowing the source and receiver locations to completely surround the area of interest

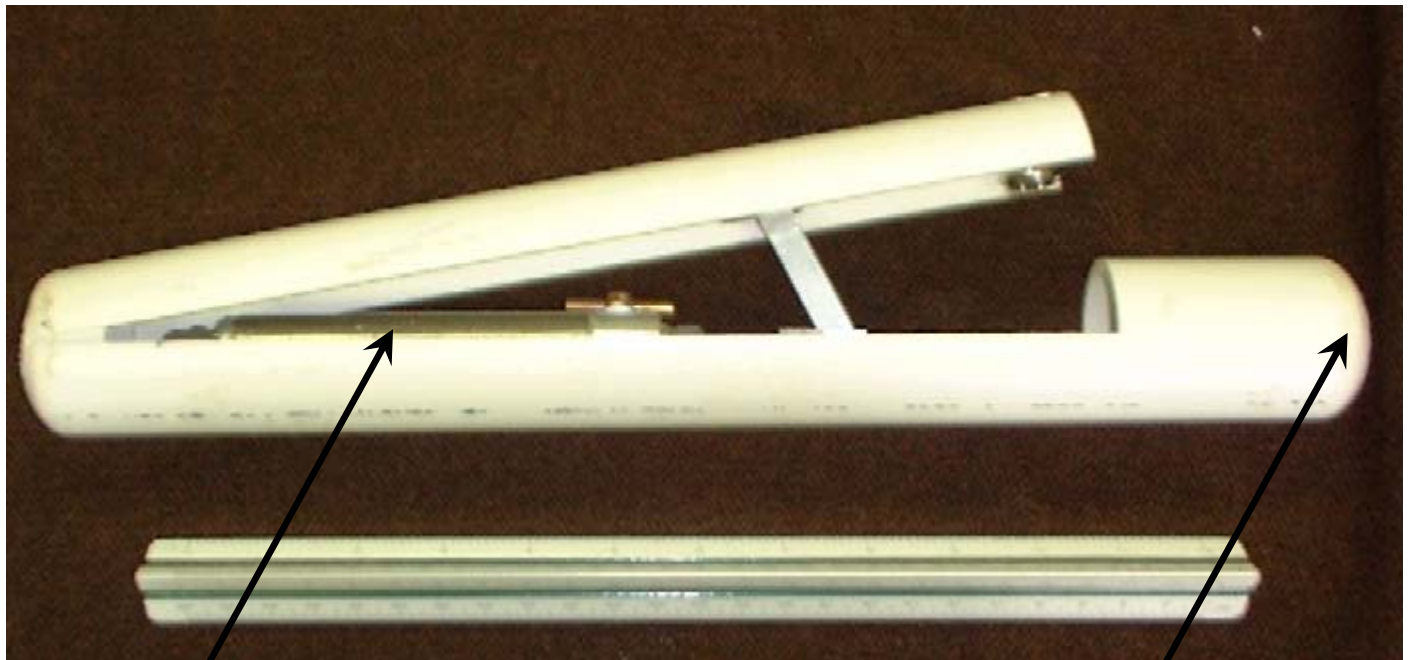


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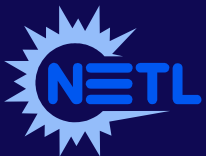
# Photo Library

Prototype design for testing at CONSOL  
underground coal mine

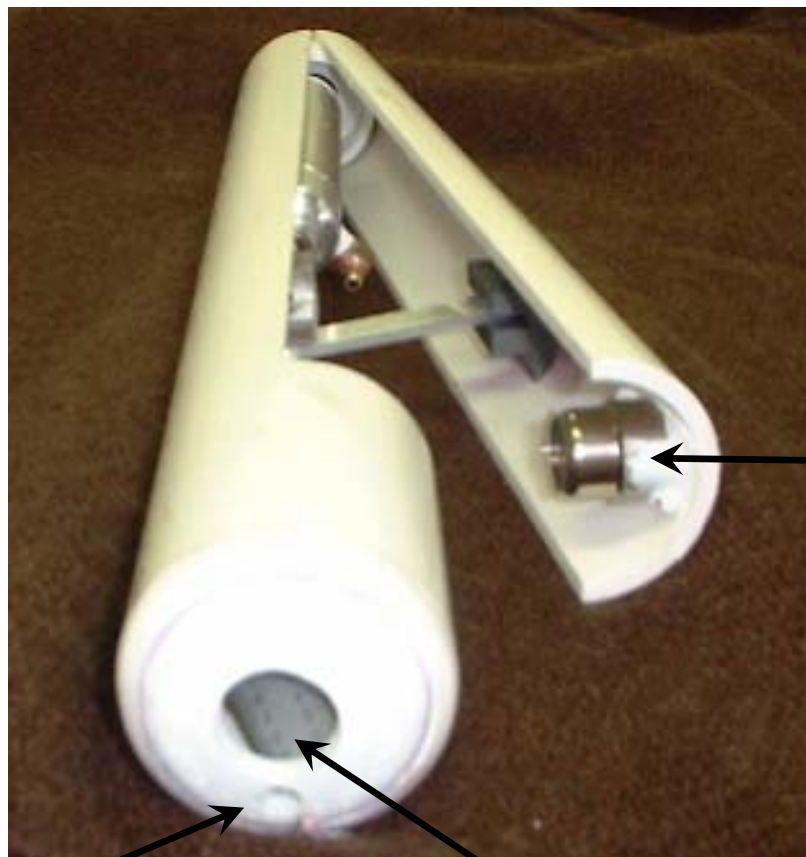


Air cylinder – retracts to  
extend clamping arm

Tapered ends to  
facilitate placement



# Photo Library

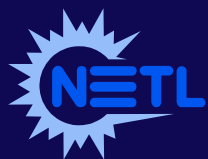


Geophone

Air line inlet

Signal cable inlet

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# Milestones and Status

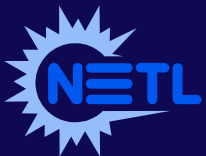
- **Major Milestones Planned to Date/Status**

- **Planned Milestone**

		Scheduled	Completed
– Initial design	Apr. 01	Apr. 01	
– Prototype lab tested		July 01	July 01
– Prototype stone quarry	May 02		June 01
– Prototype mine tested		Oct 02	
– Data analysis/design mod's		Dec. 02	

- **Key Decision Points Remaining**

- Finalize design through testing of improved prototype



# Key Accomplishments

**Key accomplishments include:**

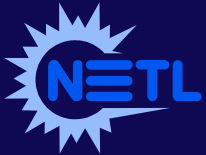
- **Initial field testing completed at CONSOL Energy's Buchanan mine. Array was ready, mine was cooperative, but hole was caved at 60 ft.**
- **Seismograph for underground field testing made available by NSA Engineering.**



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## Good News!

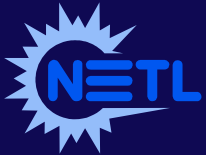
CONSOL Energy has agreed to further testing in the barrier pillar of the 5-Right panel at the Buchanan mine during May, 2003. Testing will be conducted in newer hole and with better emplacement method.



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# Project Recognition

- Oral presentation at MSHA's  
“Symposium on Geotechnical Methods  
for Mine Mapping Verification,”  
Charleston, WV, October 29, 2002



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